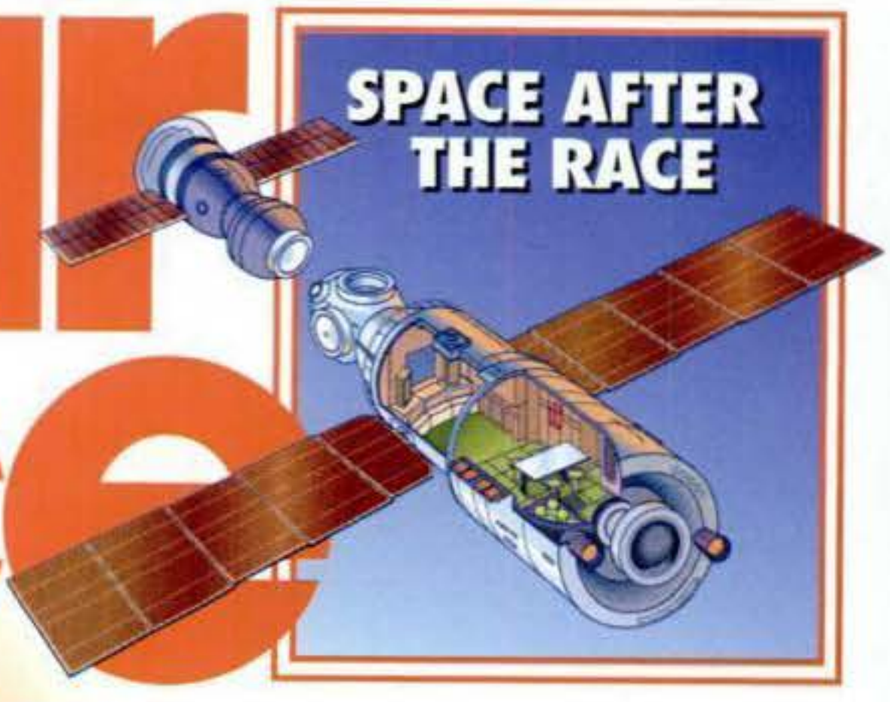
NEW PERSONALITIES FOR COMPUTERS

A Times Mirror Magazine

Popular Science



Fact Or Fantasy

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AUGUST 1993
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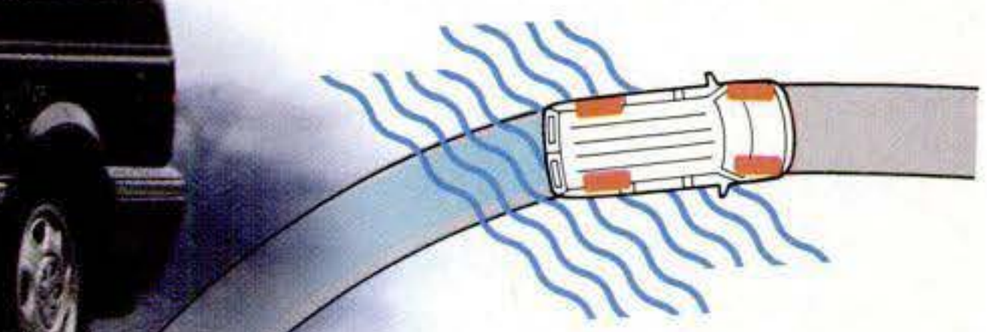

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AT'S NEW MAGAZINE

AUGUST 1993

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FOUNDED IN 1872

VOLUME 243

NUMBER 2

COVER BY TOM WHITE

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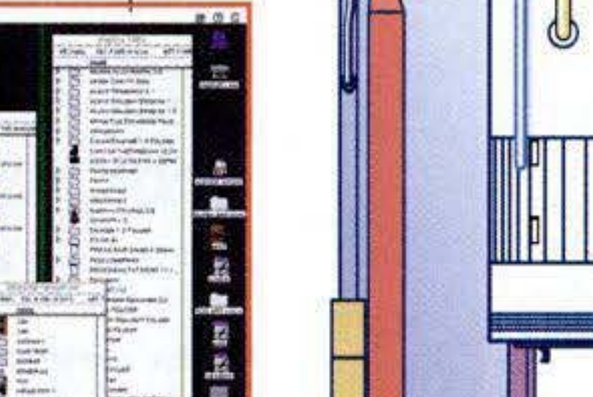

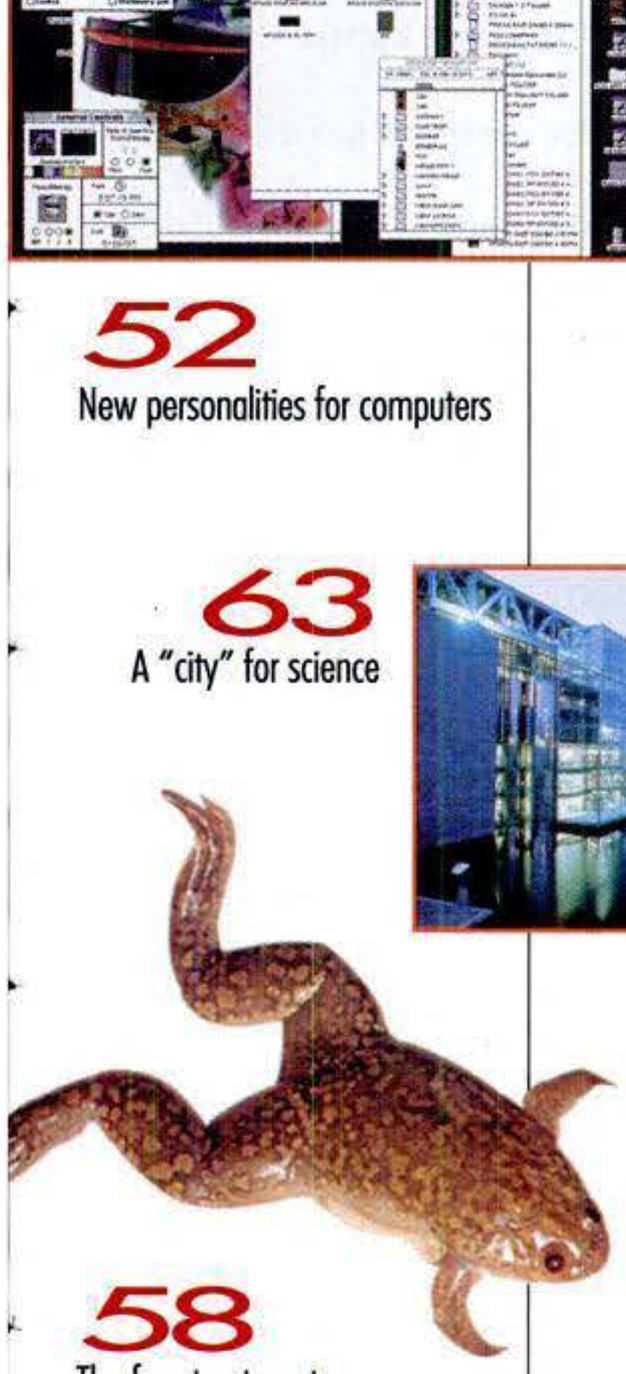

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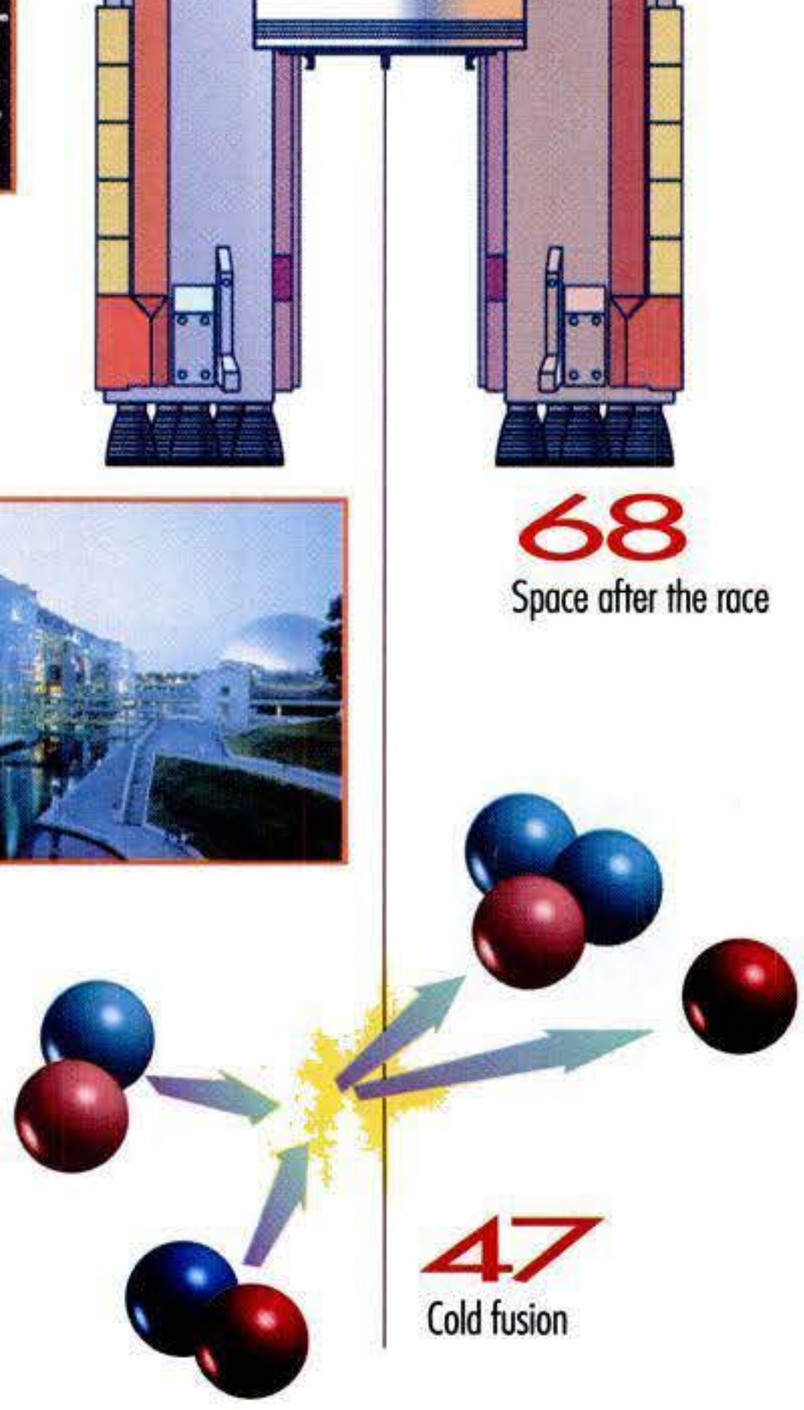
The frog treatment



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FEATURES

Cold Fusion: It Ain't Over Till It's Over 47
A grand illusion—"pathological science"—or a new source of energy from previously undetected nuclear reactions? First announced four years ago, the dream of cheap, abundant energy from a room-temperature nuclear fusion reaction in a jar refuses to die.

New Personalities For Computers 52
If the microprocessor is the brains of a personal computer, then the operating system is its personality. The essential software that controls PCs is now undergoing major renovations, making possible photo-realistic images, full-motion video, stereo sound, and other multimedia features.

The Frog Treatment 58
How do you kill diseases that have become resistant to drugs? The answer may be a new class of antibiotics that scientists are deriving from unexpected sources: sharks, moths, pigs, jellyfish, and frogs.

The Electric Eye 60
A light-sensitive chip grafted to the human retina promises rudimentary vision for some people who cannot see.

Science Cité 63
The world's biggest science museum isn't really a museum at all. Instead, it's a giant machine for popularizing science and technology, with a colorful and unusual past.

Space After The Race 68
America's space program, once a source of pride and inspiration to the nation, is now a shambles, its mission unclear, its very existence at risk. With the collapse of the Soviet Union, the arrival of a new administration in Washington, and a worldwide softening of the economy, the days of bold space-faring seem to have ended.

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EDITOR'S NOTE

The Once And Future Space Program

Back in March, President Clinton directed NASA to come up with less expensive options for space station Freedom. In a crash three-month effort, NASA acted as an "honest broker," says administrator Daniel Goldin, in offering three downsized space stations with price tags from $11.9 to $19.3 billion.

However, Congress, not the White House, holds the deciding budgetary vote. So the Reagan-era proposal to loft a permanently manned space station by the year 2000 stands a good chance of meeting its demise on Clinton's watch. Whatever the outcome, one thing is clear: America now has a political soap opera masquerading as a space program. The Space Age—conceived in the challenging words of President John Kennedy, fueled by fears of Cold War-era Soviet dominance, and proudly embraced in the hearts and minds of the American public—is fast becoming history.

What tends to get lost in all of the design-cost analyses is an honest assessment of why we need a space station in the first place. Maybe we need to kill the space station to save the program. Even the most ardent boosters would be hard pressed to justify the space station as critical to the space program objectives articulated by President Clinton and John Gibbons, his chief science adviser. High atop the short list of their priorities is the creation of new knowledge useful here on earth, such as a better understanding of the environment. International cooperation, economic benefits, and an inspirational furthering of science and math education also are among the administration's goals. Human space flight is not an objective, but is viewed as one of the many potential means to these ends.

In Space After the Race, Senior Editor Stuart Brown offers a measured analysis of where our space program has come to, and where it may be heading. Emotionally, it may be difficult for one generation of Americans to let go of a quest that created a living legacy of heroes and milestones. But perhaps the smartest thing to do is embrace the smaller, faster, cheaper vision of the current administration in the hope that it rekindles and redefines a new and newly relevant space age for the next generation.

Jerry Bishop, the author of this issue's cover story, was a young and aggressive science reporter at *The Wall Street Journal* when I was beginning my journalism career there as a copy boy. By the time I joined POPULAR SCIENCE in 1989, Jerry had earned many a science writing award, including the coveted American Institute of Physics Writing Award for his groundbreaking reporting on the cold fusion experiments of Stanley Pons and Martin Fleischmann. Bishop's new report brings us up to date on the cold fusion controversy that just won't die. Despite the frustrations of believers and the claims of fraud by detractors, cold fusion research is gaining new support and funds, especially overseas. Bishop's report on the fact-or-fantasy debate over cold fusion should convince you that in science, as in baseball, it ain't over till it's over.

EDITOR-IN-CHIEF

GILES CHERRICK

NASA chief Daniel S. Goldin (left) details a "smaller, faster, cheaper" space program to Editor-in-Chief Fred Abatemarco.

Popular Science

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READERS TALK BACK

PATRIOT PERFORMANCE

Sons of the Patriot" [June] editorializes, misinforms, and makes conclusions with questionable authority.

In the Persian Gulf war, according to the U.S. Army, the Patriot had a 40 percent success rate in Israel and 70 percent in Saudi Arabia—hardly "less-than sterling." In fact, Raytheon's Patriot missile enjoyed greater success than most weapons systems, and it helped keep the number of civilian casualties below those resulting from previous encounters with ballistic missiles. And the Patriot wasn't even designed to counter this particular threat. What you called "23-year-old Patriots" were PAC-2 versions just developed with the latest technologies.

Using videotape to judge success, discussed in the related story, "Gulf War: Let's Go to the Videotape!" has been criticized by many independent analysts. Missing from the article was the congressional General Accounting Office's (GAO) conclusion that "videos produced by television crews cannot be relied on to [decide] how many Scud missiles were hit or missed by the Patriot during the gulf war."

Your conclusion that the Army's methodology was more flawed than the video analysis was based on several erroneous judgments by the GAO. Most surprisingly, you found video analysis—that "bright spots descending over the horizon" on the videotape could only be Scuds—more accurate than actual ground inspections by Army teams. Furthermore, your explanation for low civilian casualties —that many Scuds fell into the Mediterranean Sea—is absurd; the vast majority of Scuds were headed toward populated areas.

Robert M. Stein
Vice President and Manager
Advanced Air Defense Programs
Raytheon Co.
Bedford, Mass.

Since Patriot was the first anti-ballistic missile system used in combat, it's not clear what would be gained by comparing it with previous weapons. As far as its age, Patriot was first built in the 1960s and tested in 1970. While the missiles used in the gulf war were newer versions modified to shoot down Scuds, most of the technologies involved were old.

Stein notes that I fail to mention a GAO report that criticizes his opponents in the debate over Patriot's success rate. Fair enough. But he offers no alternatives to what the videotaped "bright spots" were, if they were not Scuds. —Robert Langreth

PATE PROTECTION

I hope the author was wearing a helmet when she tested the bikes in "Easy Riders" [May]. Helmets mess up your hair, but not as much as brain surgery.

Mike Easley
Laguna Beach, Calif.

A helmet prevented me from getting seriously hurt while testing the bicycles. When photographed for the "Editor's Note," however, I was not riding—and therefore did not wear a helmet. —Marcelle M. Soviero

SUSPECT SUBJECTS

That Nikonos RS underwater camera in "Underwater Wizardry" [June] was *truly* miraculous: It even created a conch with pincers instead of a foot! What you called a living conch is really a hermit crab inhabiting an old conch shell.

Mary Wister Rawlins
Tri-Cities, Wash.

Corrections: The term VOR stands for "very high frequency omnirange" ["Electronics Newsfront," June].

Hako International ["What's New," July] has moved to Box 7698, Arlington, Va. 22207.

In "Adobe Bends Over Backward to Kick the Paper Habit" ["Computers & Software Newsfront," April], the software is called Common Ground and the company's name is No Hands Software. No Hands Software has moved to 1301 Shreway Rd., Suite 220, Belmont, Calif. 94002.

In "Sons of the Patriot" [June], the opening description of a typical Scud missile battle in Israel during the Persian Gulf war should have located the engagement in Tel Aviv.

The article also should have said that ballistic missiles enter the atmosphere at an angle of 30 degrees from the vertical, rather than 30 degrees from the horizontal.

Address letters to Readers Talk Back, POPULAR SCIENCE, 2 Park Ave., New York, N.Y. 10016. Or fax your letter to us at 212-481-8062. Letters may be edited for space and clarity. We regret that we cannot answer unpublished letters.

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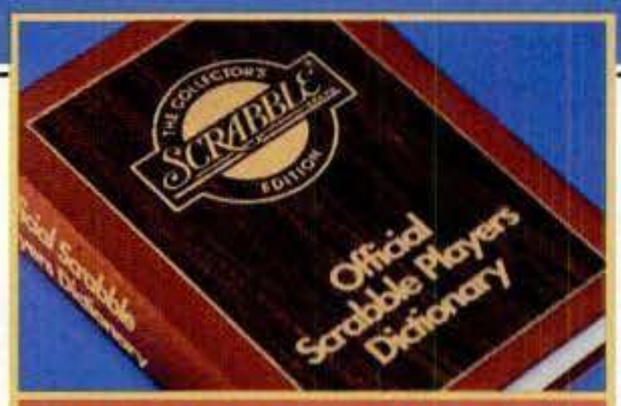

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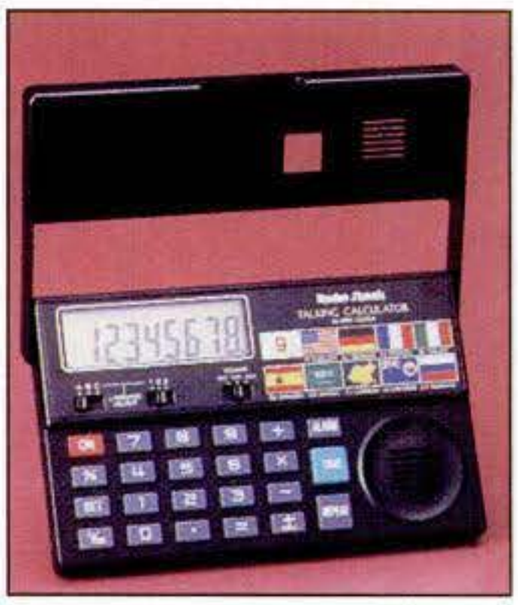
WHAT'S NEW

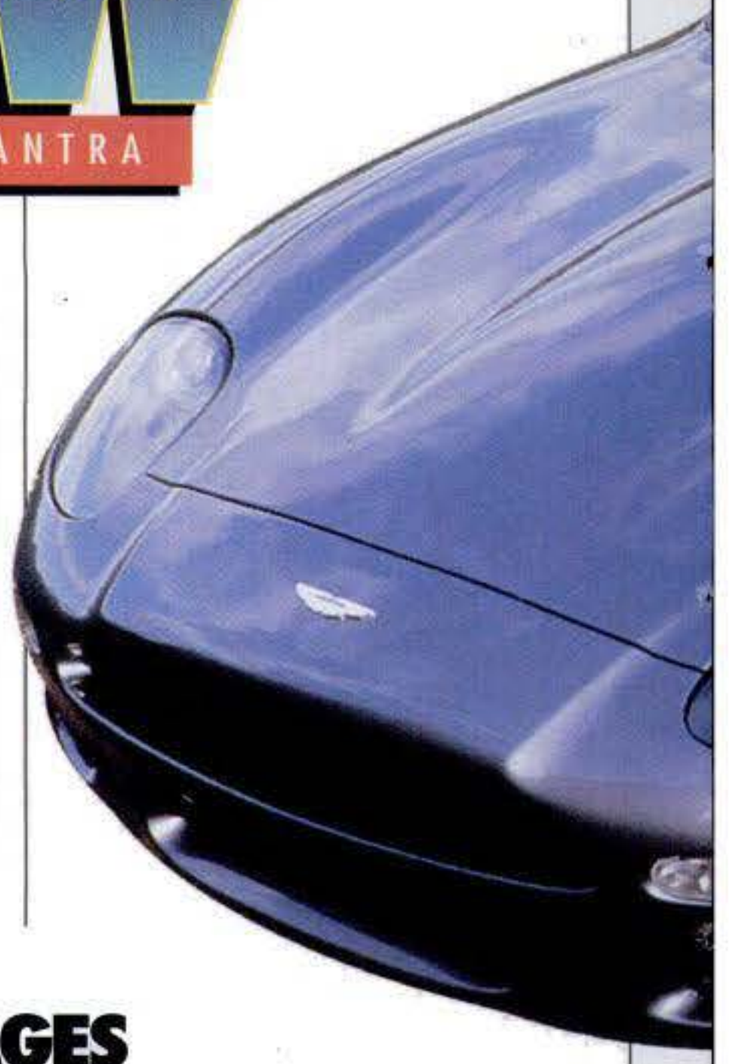
EDITED BY MARCELLE M. SOVIERO AND SUZANNE KANTRA

NEWSPEED

THE WORLD AT YOUR WRIST

The Seiko Receptor watch displays personal messages, stock market information, weather reports, and sports scores —as well as the time. The device receives data via a radio frequency broadcast by Seiko. Available now in the northwest United States, and soon nationwide, the watch costs $169, plus a $12.50 monthly service fee.





HAGGLE IN EIGHT LANGUAGES

Radio Shack's EC-210 Talking Calculator helps travelers compute prices in other currencies—and delivers the answer in eight languages, including Arabic, Chinese, and Russian. The $30 unit features an eight-digit liquid-crystal display and a digital alarm clock.

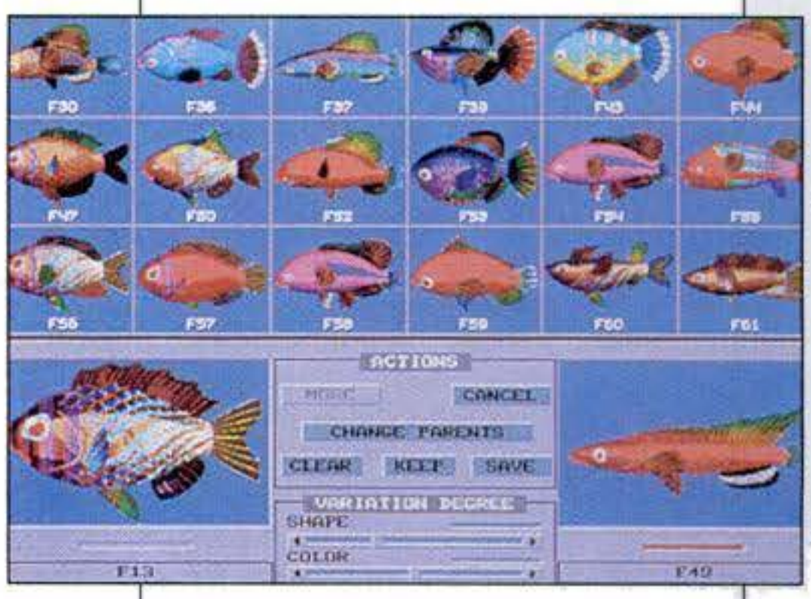
THERE WHEN YOU NEED IT

The Lite-A-Life smoke alarm hooks onto the top of a door; if it detects smoke, it sounds an alarm and activates a two-beam light. You then can detach the device and use it as a flashlight to help guide you to safety. Price: about $45. The Hyland Co., 123 Kingwood Dr., McMinnville OR 97128.

BRUSH CUTTER

For improved maneuverability and control, Troy-Bilt's sickle-bar mower features power steering and anti-vibration handlebars. It cuts through dense vegetation, including saplings, and has an eight-inch ground clearance. Three models offer 3.5-, 4-, and 5-hp engines. Price: $1,349 to $1,719. Troy-Bilt, 102nd St., 9th Ave., Troy NY 12180.

STEVE STANKIEWICZ



DESKTOP AQUARIUM

With El-Fish software, you create an electronic aquarium, complete with fish, aquatic plants, and coral. An artificial-life program enables the fish to crossbreed and mutate to form exotic new species. A 386 computer, VGA monitor, and four megabytes of RAM are required. Price: $60. Maxis, 2 Theatre Square, Suite 230, Orinda CA 94563-3346.

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AWESOME ASTON

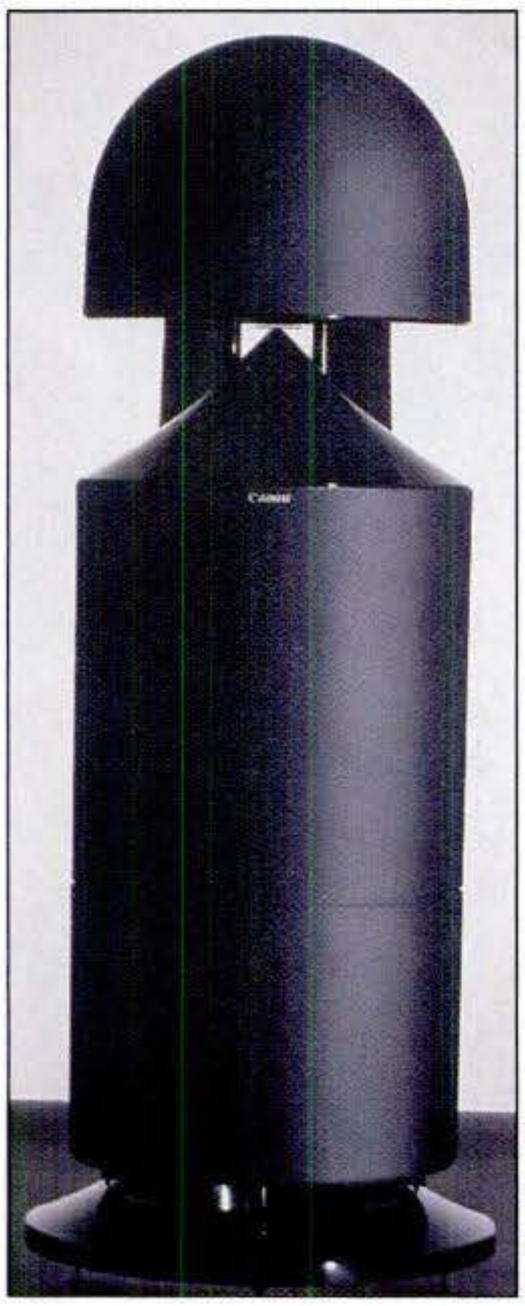
Barely 15 feet long, the Aston Martin DB7 emerges as Britain's baby supercar—accelerating from 0 to 60 mph in 5.5 seconds and reaching 165 mph. It has Jaguar's 3.2-liter in-line six-cylinder engine that, with turbocharging and intercooling, puts out 335 hp. Both a five-speed manual and a four-speed electronic automatic gearbox are available. Price: $115,000.

HANG-ON-THE-WALL FAX

Sharp's NX-1 Home Fax combines a fax, phone, copier, and answering machine in a hang-on-the-wall unit that hooks up to a standard phone line. A memo pad function lets you record phone numbers, which are stored for automatic redial or printed for future use. Price: $495.

SODA BUBBLER

This reusable soda dispenser keeps beverages carbonated. The $7 Soda Matic uses the carbonation to propel the liquid up through the straw; the device fits all standard screw-top soda bottles. Soda Matic USA, 7056 Convoy Ct., San Diego CA 92111.



MUSIC MIRROR

Canon's dome-shaped stereo speakers direct sound onto a sloped, curved surface. This is claimed to disperse the sound evenly and increase the listening area as much as six times over conventional speakers. Sold only in Europe, the speakers come in pedestal, bookshelf, and desktop models.

UNDERWATER EYES

A design prototype, the portable Explorer underwater sonar device could someday help scuba divers locate other divers, shipwrecks, or coral reefs. Equipped with a back-lit liquid-crystal display, the Explorer takes depth readings of up to 400 feet. Integrity Design, 419 E. 13th Ave., Columbus OH 43201.

See POPULAR SCIENCE's What's New products July 17 and 18 on CNN'S *Science & Technology Week*, which airs every Saturday at 11 a.m. and Sunday at 12:30 p.m. Eastern Time

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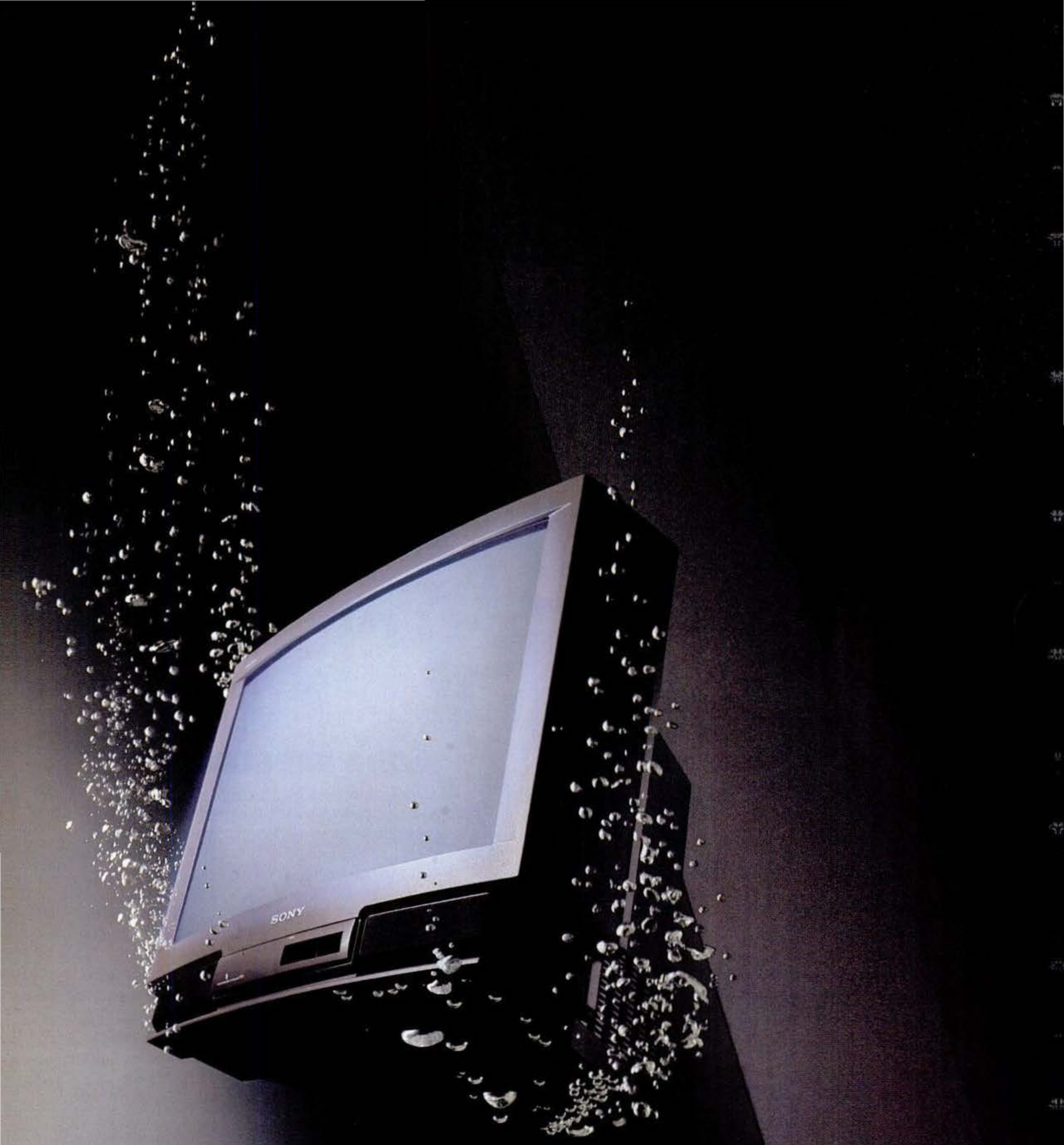

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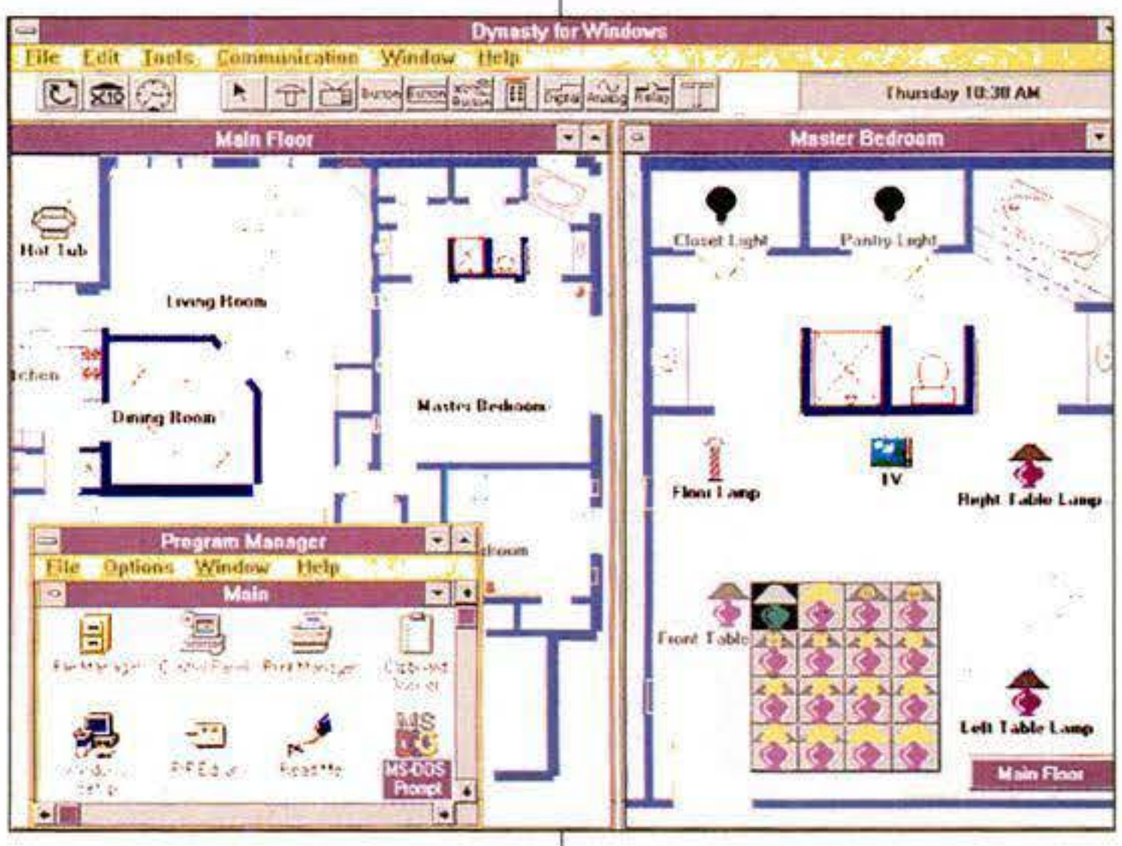
WHAT'S NEW

SLEEK STUDY

This Mercedes coupe design is distinguished by a tinted glass roof that merges into its windshield and a hatchback that extends to the rear bumper. Frameless windows complete the greenhouse styling. The concept car is based on the 500E platform and uses the same 315-hp five-liter V8 engine.

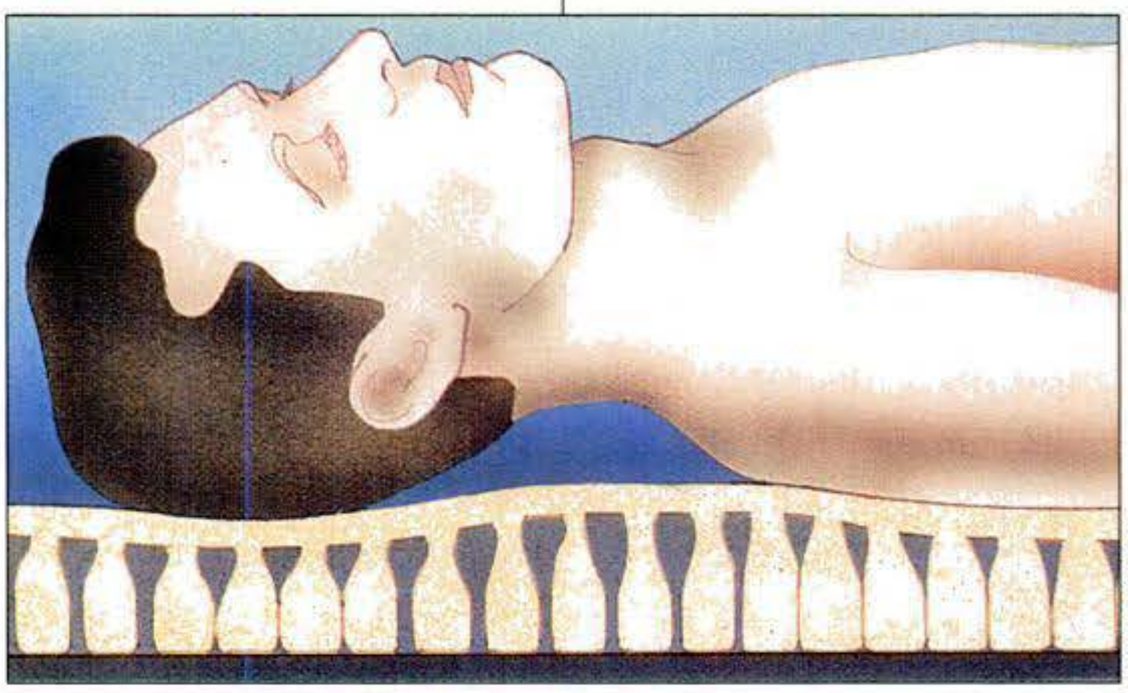


AUTOMATION SOFTWARE

Unlike other home-automation programs that often require a dedicated computer, DynaPac Windows I runs in background while you use other programs. The package includes hardware that controls up to 256 lights and appliances. Price: $899. Home Automation Laboratories, 5500 Highlands Pkwy., Suite 450, Smyrna GA 30082-5141.

SWING TRAINING

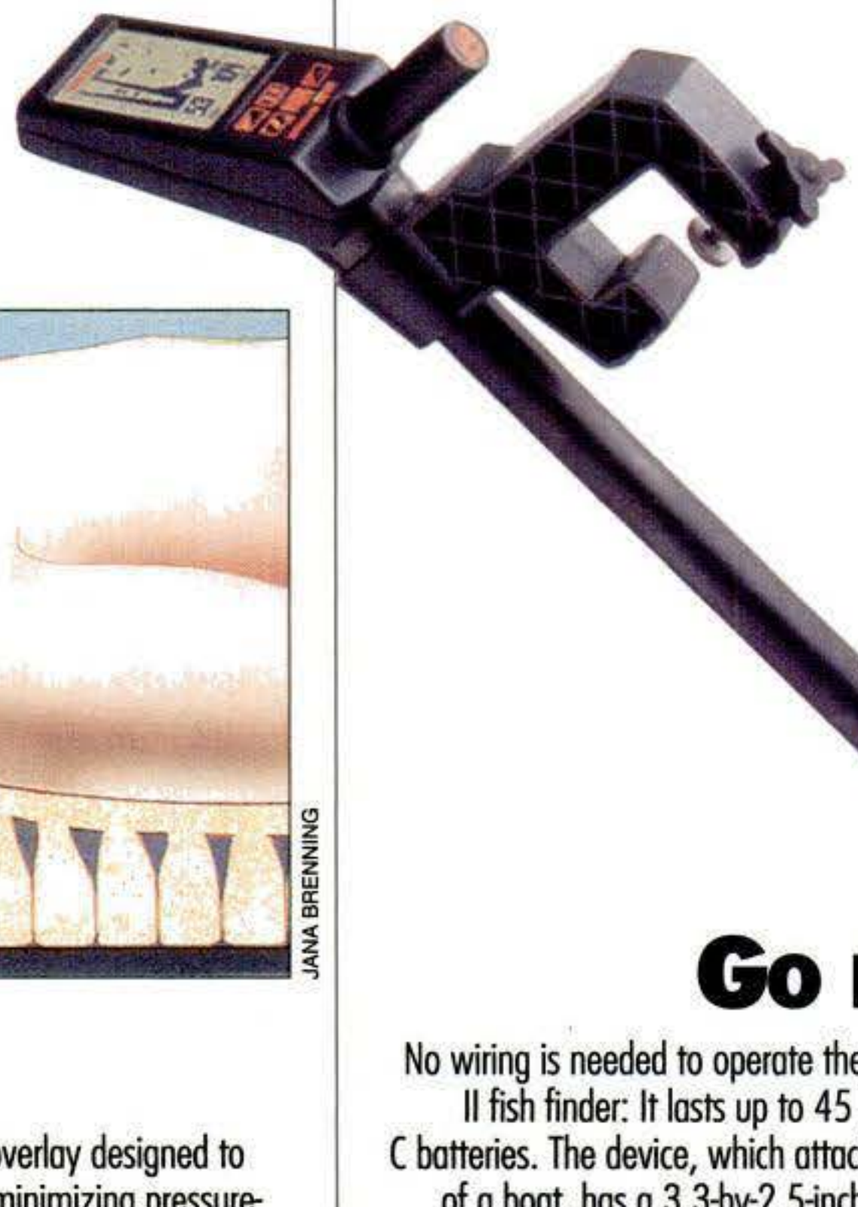
The SwingPro enables golfers to perfect their grip while increasing the strength and flexibility of their swing. The $70 device consists of a one-pound steel bar with two four-pound weights at each end; interchangeable grips and weights are available. Concept Sports, Box 7088, Grand Ave. Station, Des Moines IA 50309.



JANA BRENNING

SCULPTED SUPPORT

The Delta Foam Support System is a polyurethane mattress overlay designed to better support and distribute the weight of hospital patients, minimizing pressure-induced tissue damage. When weight is applied, the foam columns on the underside of the mattress press against each other, forming a more rigid surface. Price: $47. BFD Industries, 300 W. Wieuca Rd., N.E., Bldg. 1, Suite 200 Atlanta GA 30342.



GO FISH

No wiring is needed to operate the Fishin' Buddy II fish finder: It lasts up to 45 hours on three C batteries. The device, which attaches to the side of a boat, has a 3.3-by-2.5-inch back-lit liquid-crystal display that registers side and depth measurements simultaneously, as well as water temperature. Price: $149. Bottom Line, 499 E. Corporate Dr., Meridian ID 83642.

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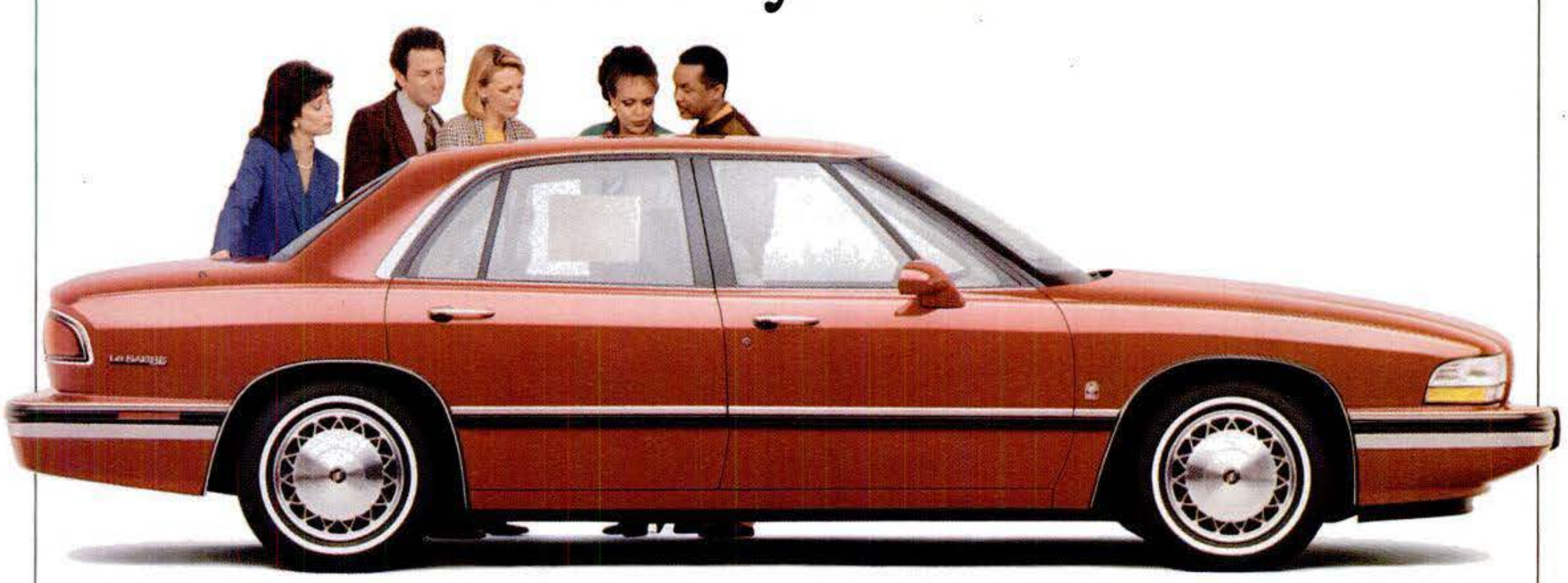

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Value. It's spelled out right there in black and white, at the bottom of the sticker. The price of the 90th Anniversary Buick LeSabre.*

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The 90th Anniversary LeSabre is our anniversary gift to you. So drive one home. Oh, about the sticker—go ahead, take it off. Keep them guessing. For more information, see your Buick dealer today or call 1-800-4A-BUICK.

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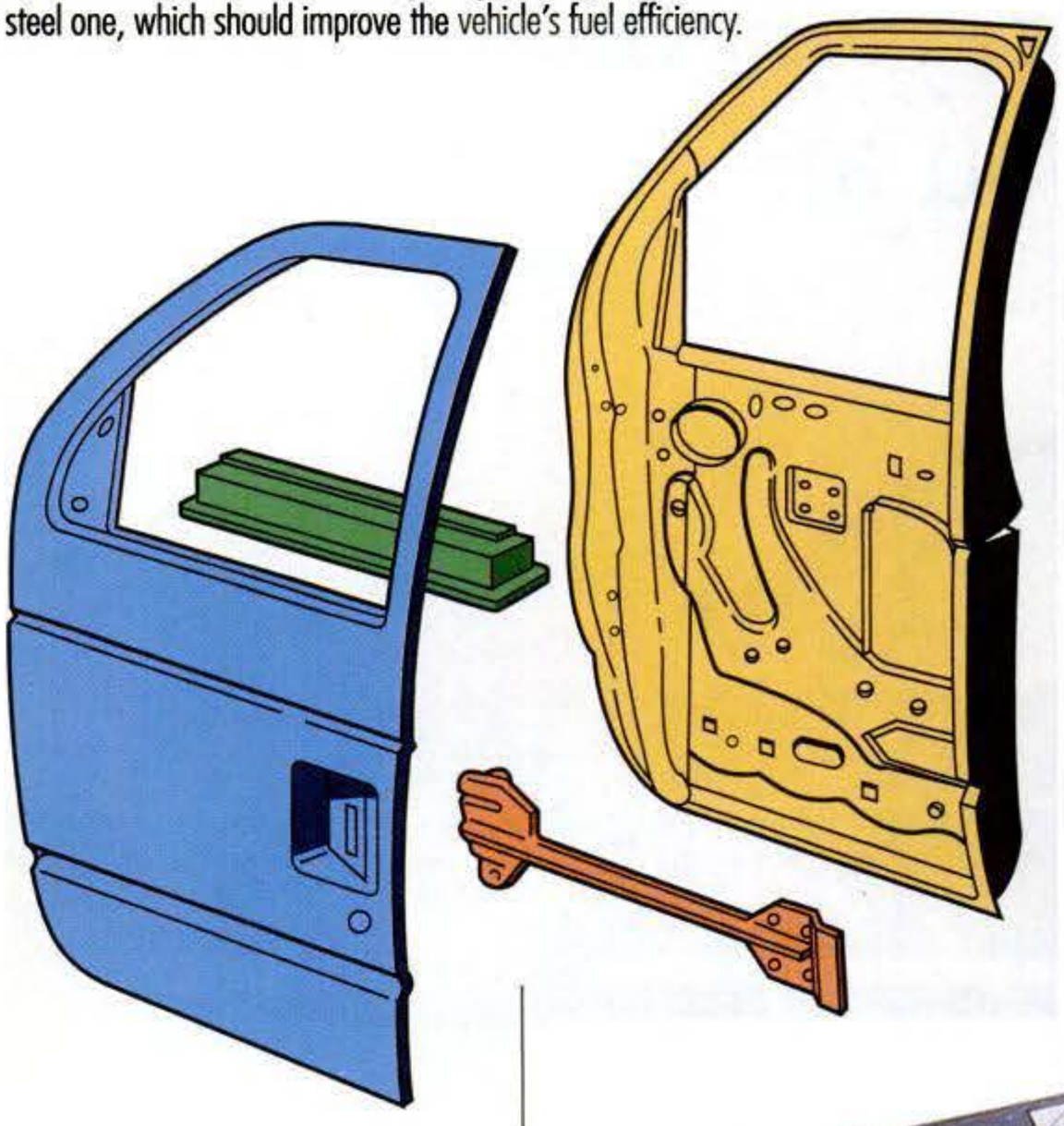
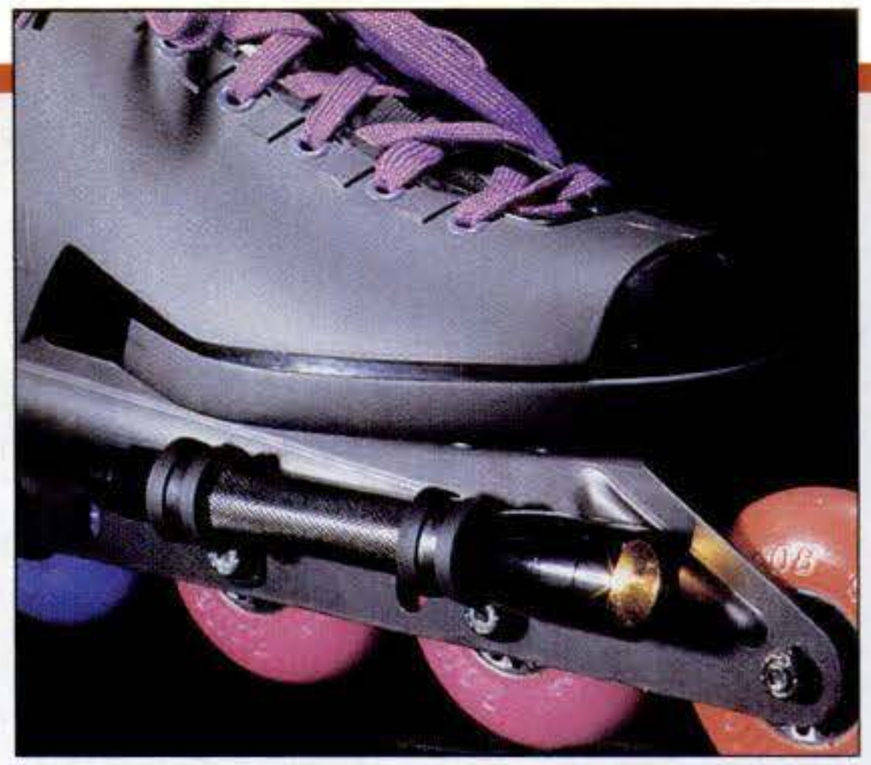
WHAT'S NEW

HYBRID CAR DOORS

An experimental door for cars combines the strength of steel and the dent resistance of plastics. Developed by the Budd Co. in Troy, Mich., the door's outer panel is made of a resilient composite of fiberglass, limestone, and resin. Combined with a steel inner panel, the door weighs significantly less than an all-steel one, which should improve the vehicle's fuel efficiency.



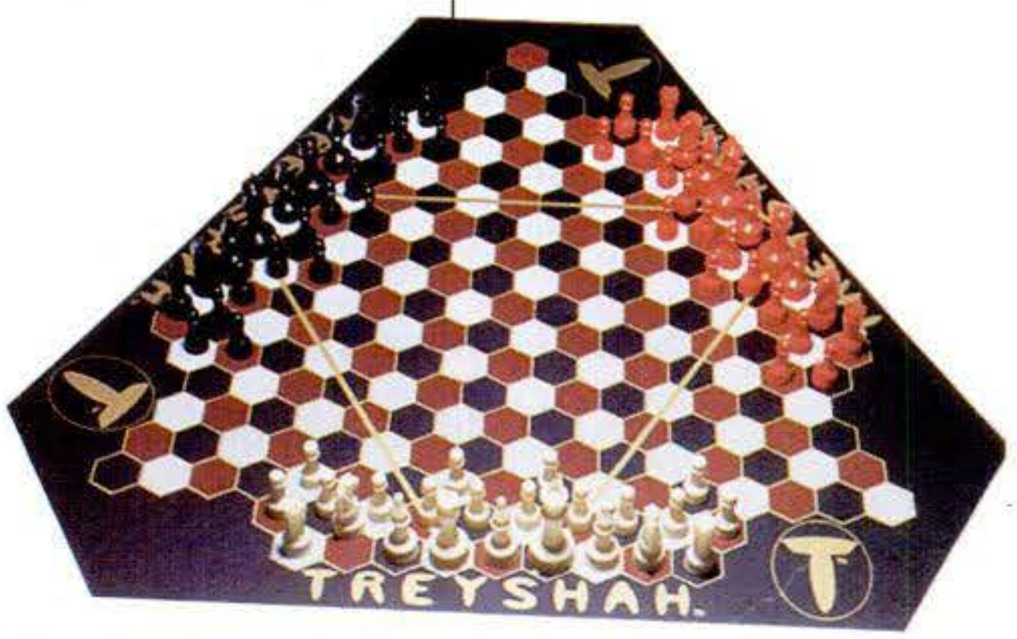


BRIGHT LIGHTS, BIG LANES

Skatelites attach to most in-line skates, providing 12 feet of forward visibility. The $30 battery-powered lights, which come with mounting brackets, use replaceable krypton bulbs that last approximately 15 hours. Paragon Racing Products, 690 Industrial Circle S., Shakopee MN 55379.

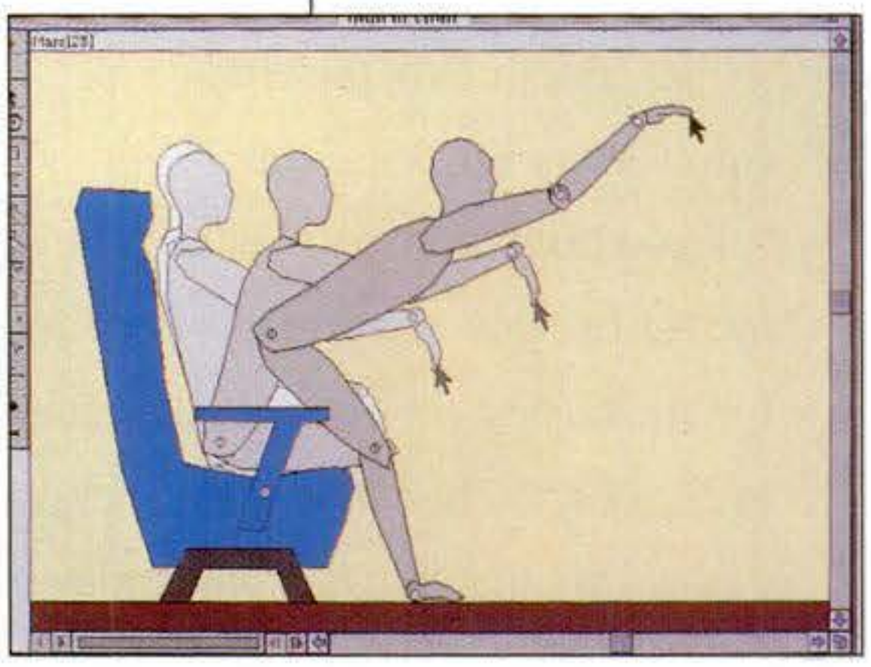
IMPRINT YOUR PRINTS

The $449 Ricoh Shotmaster Zoom 105 Plus 35mm lens/shutter camera has a remote control that stamps up to 20 characters' worth of information—such as the time, date, or name of subject—onto the film. The $90 RC-5 remote control operates nine other modes, such as continuous shooting and multiple exposure.



CHESS FOR THREE

The Treyshah (three kings) chess game adds a third player to the traditional format. The board has hexagonal spaces, so playing pieces can move in six directions instead of four. The $25 Players Edition (shown) uses a flexible board that stores in a canister; a $100 acrylic Tournament Edition is also available. Shah Games, Box 701431, Salt Lake City UT 84170-1431.



MARVELOUS MOTION

Useful for both engineers and animators, Working Model software simulates objects in motion. The objects are created with physical properties such as weight and elasticity, then placed in an environment in which they move according to the laws of physics. Price: $995. Knowledge Revolution, 15 Brush Place, San Francisco CA 94103.

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IT STARTS EACH DAY COLD, NAKED AND VIRTUALLY UNPROTECTED.

Your poor engine. At start-up, it's only protected by a thin film of oil. It has to wait precious moments for more oil to be pumped up from the pan. The result? Friction and metal-to-metal contact. In fact, most engine wear occurs at start-up. Help stop it by using new STP® Engine Treatment with XEP2.™ This breakthrough formula actually bonds to internal engine parts providing protection from the moment you turn the key. Durable protection proven in independent lab tests to stay put, start after start. Don't send your engine out into the world without new STP Engine Treatment. Help stop engine wear before you start.

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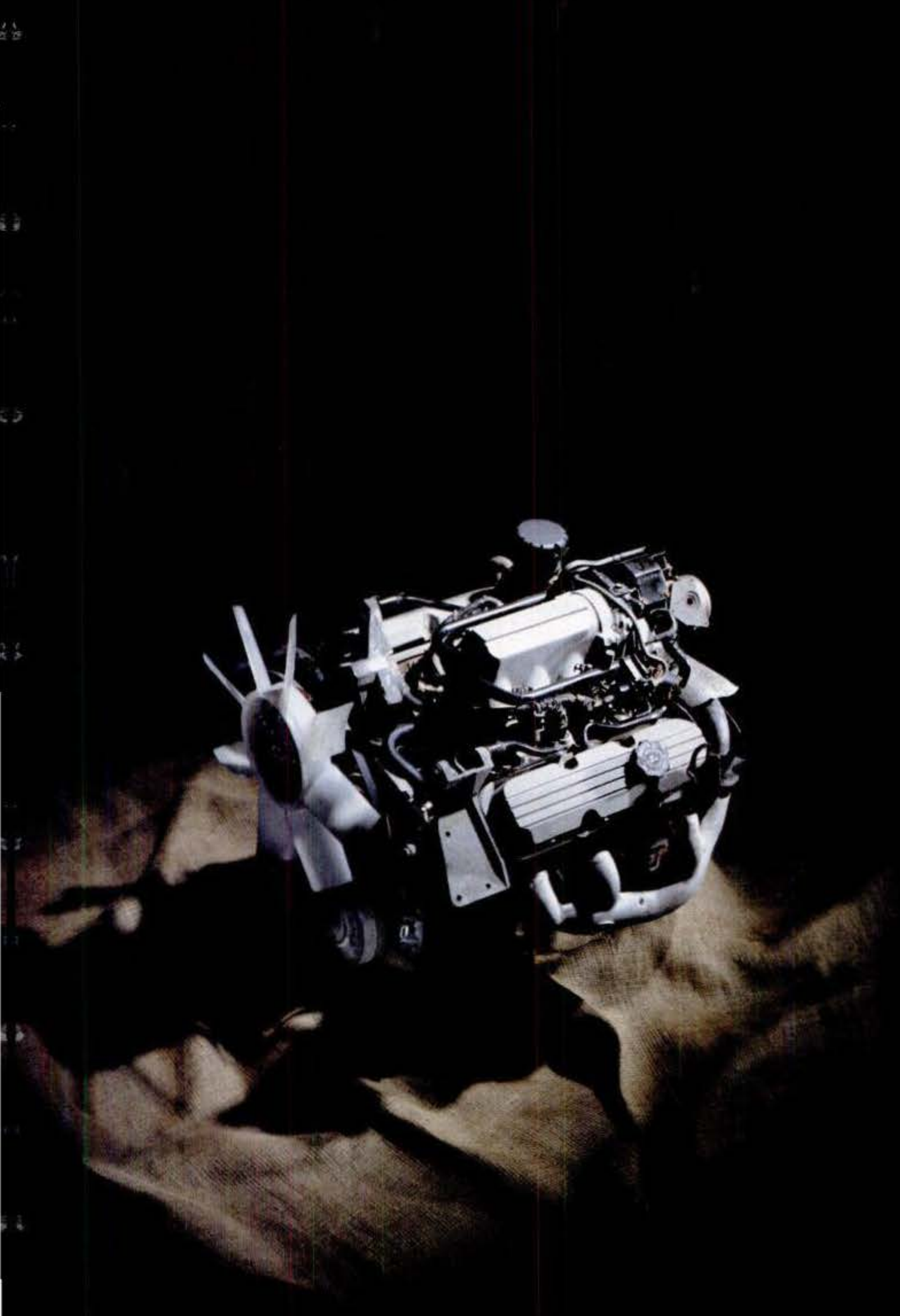

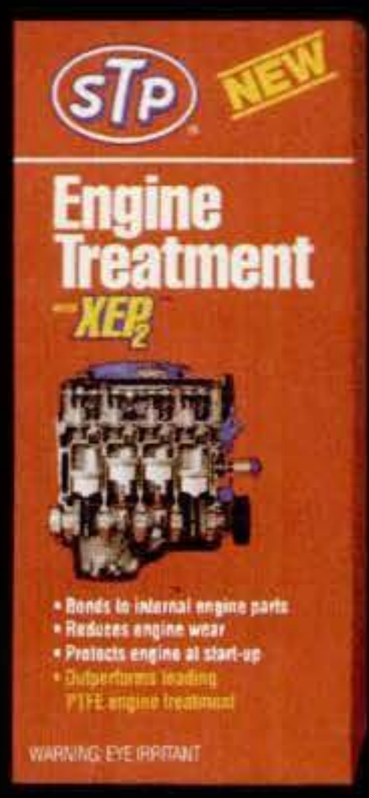

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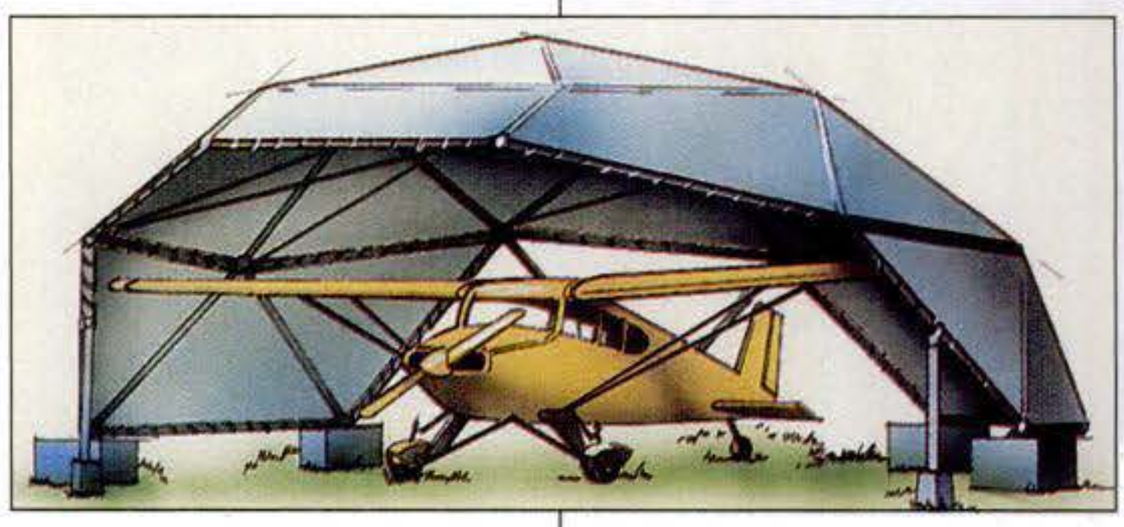
WHAT'S NEW

GEOMETRIC TENT

Because they have no supports inside or across the front, Kyner portable shelters are suitable for use as airplane hangars, pool or patio covers, bandstands, or outdoor exhibit shelters. The geodesic dome-shaped structures cost approximately $10 per square foot of covered ground. Kyner Shelters, 6404 Sunburst Lane, Box 381, Cashmere WA 98815.



JANA BRENNING

SOUND SHOWS

To create portable photo-and-audio compact-disc presentations, plug the Philips CDF100 into a TV or computer's standard RCA-composite video jack. The battery-operated unit features viewing functions such as image rotation, pan, and zoom, and comes with a remote control. Price: $599.

OVAL AUTO

The prototype Ellipsis III's diamond shape reduces drag for better fuel mileage and helps minimize damage in frontal collisions by deflecting the car. The mid-mounted engine drives the center wheels; the nose and tail wheels pivot in opposite directions for improved maneuverability. Philippe Charbonneaux, 84 Ave de le Republique, 52100 St. Dizier, France.

FLIP A LID

The Flip-Top battery has a built-in recharging device: Pull up the plastic top and plug the exposed alternating-current prongs into a wall outlet. The battery recharges in 12 hours, up to 500 times. Price: $13 for two D-size cells; other size cells should be available soon. Power Battery Holding Corp., 16301 N.E. 8th, Suite 250, Bellevue WA 98008.

ENTIRELY UPGRADEABLE

Lexar's new line of PCs is the first to offer an upgradeable Expansion Bus—the circuit wires that enable parts of the computer to communicate. Its Master Bus Slot accommodates an ISA-standard bus card, two local bus cards, and any future cards. Lexar Systems, 301 N. Harrison St., Princeton NJ 08540.

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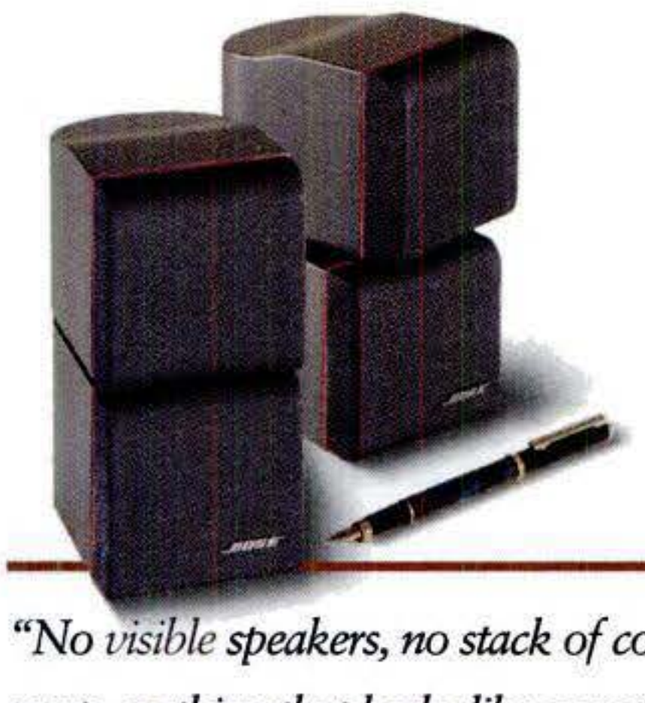

"No visible speakers, no stack of components, nothing that looks like sound equipment.... Hit the start button and suddenly the room fills with music of exemplary clarity and fullness."

– Hans Fantel, *The New York Times*

The Bose Lifestyle® music system: music center with CD player and AM/FM tuner (above), speakers (top left, also available in white), and hideaway Acoustimass® bass module (not shown).

When you get a new stereo, why not get one that's really new.

Today, most "new" stereo equipment looks and sounds about the same as it did 20 years ago.

So, is there really anything new?

The experts say there is – the Bose® Lifestyle® music system. New in its technology. New in its elegance. New in its convenience. All with the unmatched sound quality that has made Bose the most respected name in audio.

Fill your room with music, not equipment

The elegant, brushed aluminum music center replaces the bulky, complicated equipment of the past. No larger than a folded Sunday newspaper, it houses the compact disc player and AM/FM tuner.

The Virtually Invisible® speakers are the size of small bookends rather than end tables. And the remote control works around corners and through walls (including wood, brick, and stone) so command of the system is always right at your fingertips. From any room in your home.

Turn your living room into a concert hall

Exclusive Bose Direct/Reflecting® speaker technology uses the side walls of your room to reflect sound in much the same way as the best concert halls. Your entire room comes alive with music.

Hear it at home – with no risk

The best place to test a quality stereo system is in your own home.

You're invited to hear the award-winning Lifestyle® music system with a leisurely 14 day tryout. If you enjoy music more, keep it. If not, return it for a full refund. Period.

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WHAT'S NEW

COMPUTER PAD

With the Inforite MP100 notepad, you can add a handwritten notation or signature to any DOS or Windows document or spreadsheet. Three buttons enable you to switch the device between mouse and writing modes. Price: $299. Inforite Corp., 1670 S. Amphlett Blvd., Suite 100, San Mateo CA 94402.

WIND AND WATER

This new water sport uses an enormous kite, with a 20-foot wingspan, to pull a skier along the water surface at speeds up to 40 knots (46 mph). The complete package, including kite, control bar, connecting lines, skis, and storage bag, costs about $1,495. Kiteski Inc., 5555 Santa Fe St., Suite E, San Diego CA 92109.

JANA BRENNING

BIKE BAG

Made of rip-resistant nylon, the Proteq Bicycle Jam bike cover fits most adult bicycles and features reinforced slots to accommodate security locks. The cover can be folded into a small carrying case when it's not being used. Price: $35. Proteq Bicycle Jams, 116 Palmer, Houston TX 77003.

IN THE SPOTLIGHT

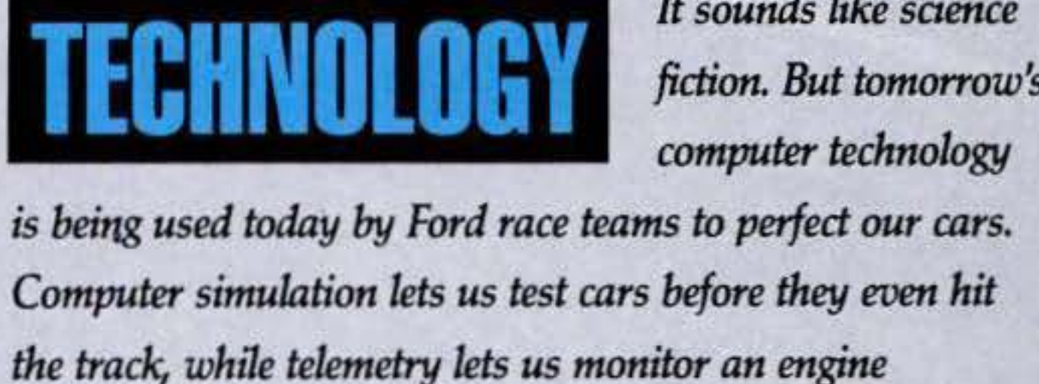
Canon's two-pound E520 8mm camcorder is the first to feature a built-in pop-up video light. When not in use, the light folds into the unit. Other features include a 10X zoom lens and seven-mode high-speed shutter. Price: $1,200.

FOR TRAIN BUFFS

The National Railway Museum in York, England, is computerizing its collection of more than 750,000 photographs dating back to 1866. Once the images are scanned and stored on optical discs, visitors will be able to view and manipulate them electronically without damaging the originals. The exhibit opens next year.

TECHNOLOGY

It sounds like science fiction. But tomorrow's computer technology is being used today by Ford race teams to perfect our cars. Computer simulation lets us test cars before they even hit the track, while telemetry lets us monitor an engine without ever lifting the hood. It's race-born technology that will soon make our street cars even more responsive to you. That's why we race.



Ford

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Why We Race

Sometimes the best way to get to know someone isn't over the phone. But a hot cup of coffee. During a typical day, State Farm agent Dick Dahms talks to a lot of people. It might be on the phone. Or over a cup of coffee at the

Ol'e Depot. It's this personal attention that makes Dick such a good neighbor. And such a natural for a State Farm agent. So who better to handle their insurance than Dick? When they stop by his office, he sits down with them, goes over their coverage and helps make sure it's up-to-date. It's called a Family Insurance Checkup. The advice is free — the decision is theirs. State Farm? It's about small towns. And good neighbors who are there for you. Like a good neighbor, State Farm is there.®

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SCIENCE & TECHNOLOGY

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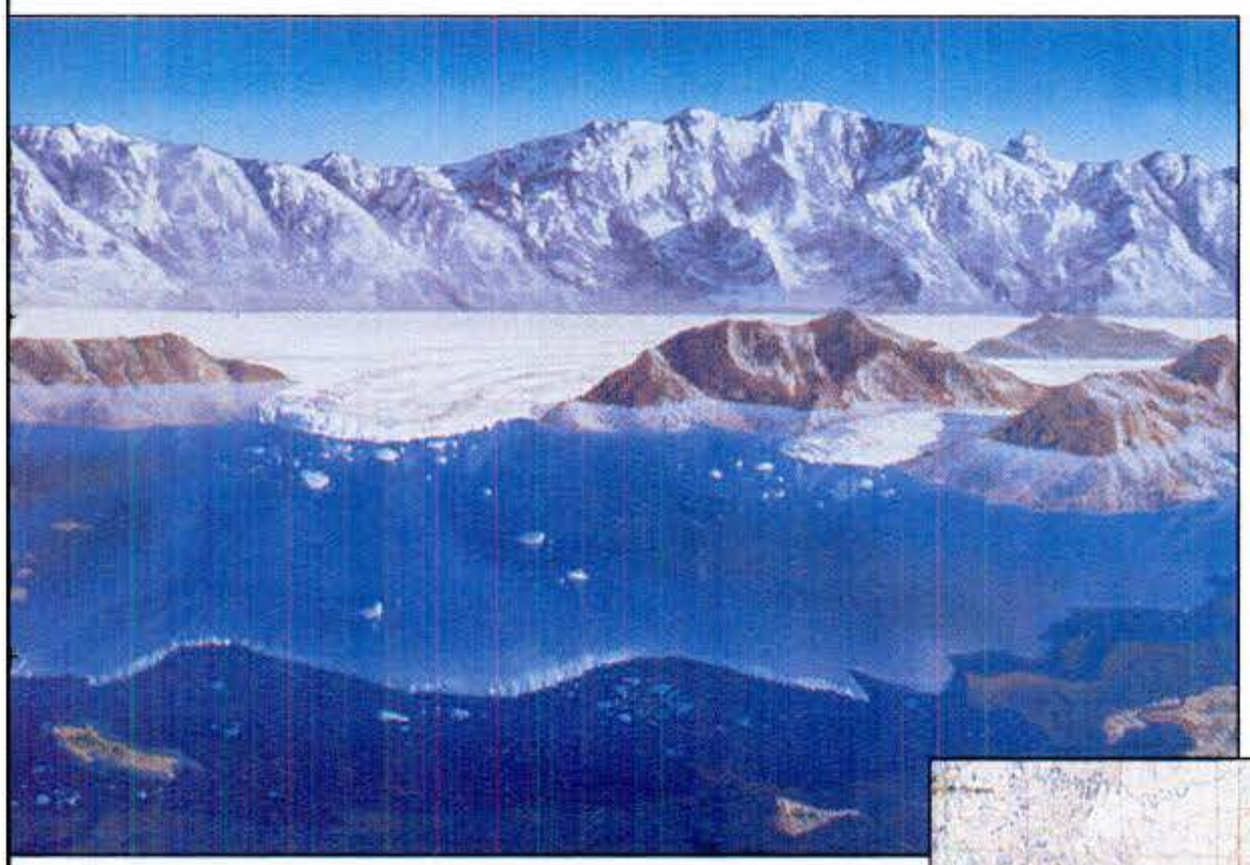
GEOLOGY

BIRTH OF A NEW SEA?



If the Bering Glacier recedes as far as the brown hills in the center of this painting (top), the area now covered by ice will become an open sea. A beach (bottom of painting) that shields shipping lanes from icebergs will erode, leaving only a few islands.

MICHAEL CARROLL

For several years, scientists have suspected that the Bering Glacier, a massive ice sheet ending near the Gulf of Alaska, has been retreating, causing the glacier to "calve" large icebergs into an ever-deepening lake at its foot. Studies conducted by the United States Geological Survey indicate that the glacier, the second largest in North America, "may be in the process of creating a new arm of the Gulf of Alaska," says Bruce Molnia, leader of a 1992 expedition to the glacier.

A thin strip of sand called Seal Beach is thought to be the only natural barrier between the glacier's dangerous icebergs and nearby shipping lanes in the Gulf of Alaska. Tankers use these shipping lanes to transport oil loaded at the port of Valdez.

"If the Seal Beach complex fails," warns Fairbanks glaciologist Dennis Trabant, "the Bering system would open up into a huge area on the order of Yakutat Bay or Icy Bay. It would literally change the coastline of Alaska."

Two new discoveries paint an urgent picture of the situation. First, seismic data indicate that the bedrock is far below the Seal Beach sand. If the beach erodes away, there will be no underlying rock to prevent large icebergs from floating into the gulf.

Second, and perhaps more important, scientists have learned that Vitus Lake, a deep lake that extends beneath the base of the glacier, is mostly saltwater. "Icebergs will persist for years in fresh water," explains hydrologist John Gray. But icebergs disintegrate more quickly in the ocean, according to some studies. "We estimate that about 90 percent of Vitus Lake is dilute seawater," says Gray. He suspects that the salt may be contributing to the glacier's retreat.

Additionally, Trabant's radar studies have detected several canyons under the glacier that would become fjords should the beach erode away. —*Michael Carroll*

BIOHERBICIDES

WEED WHACKERS

In the war against weeds, a plant pathologist is working on a weapon that doesn't require harmful chemicals. Raghavan Charudattan of the University of Florida's Institute of Food and Agricultural Sciences in Gainesville identifies fungi that cause diseases in weeds. These are developed into bioherbicides. "I spray on the fungus, it kills the weed, and then the fungal population goes down," explains Charudattan. He has patents on two such microorganisms, which can help control water hyacinths and hydrilla, both nuisances in Florida's waterways. Human body temperatures are high enough to kill the fungi, so they pose little threat to human health.—*Mariette DiChristina*

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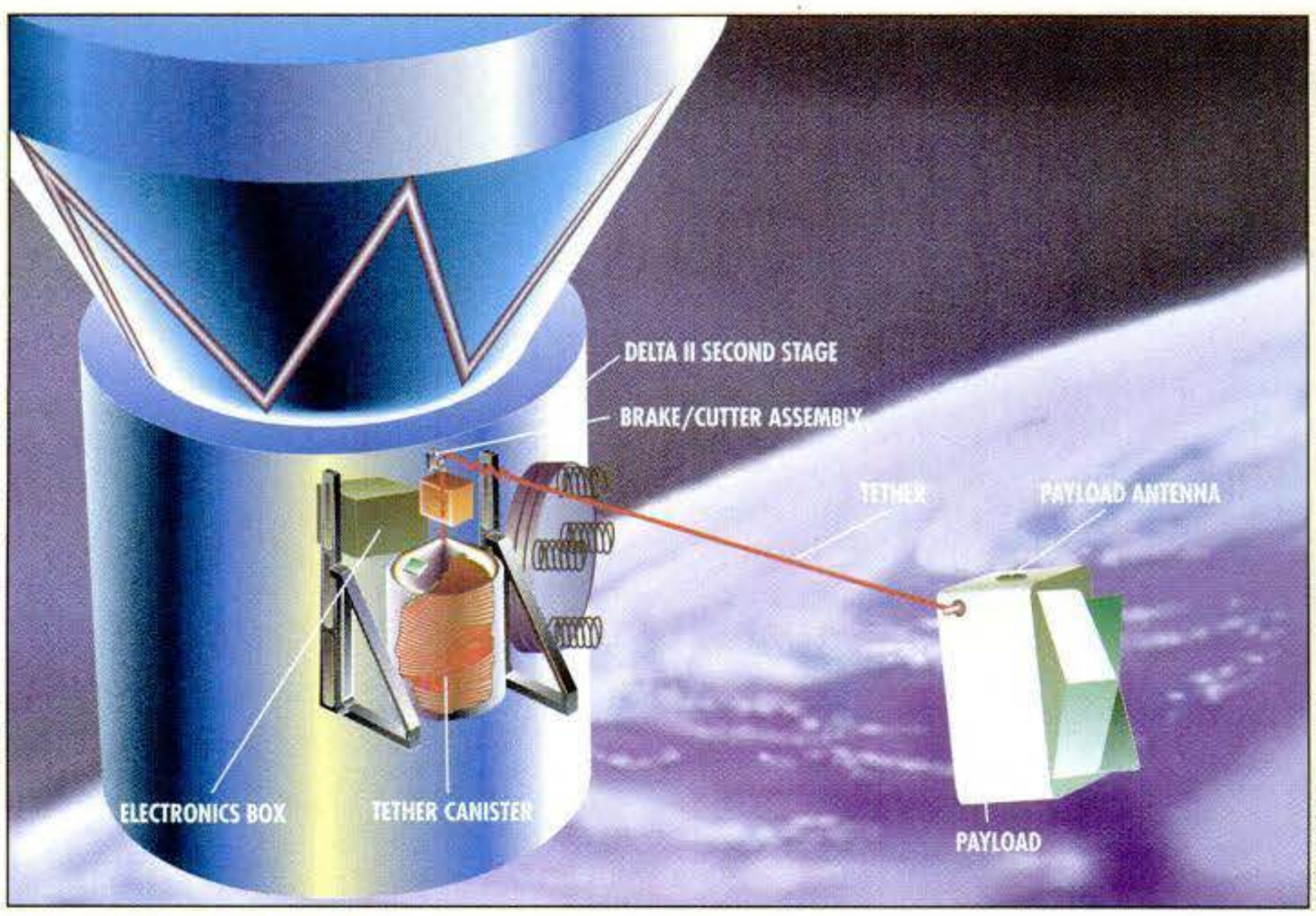
SPACE EXPLORATION



STEVE KARP

Ejected from the second-stage booster of a Delta II rocket, a small payload draws out a tether stored in a canister attached to the booster. A brake/cutter assembly above the canister slows the tether as it unwinds, then severs it to sling the payload into space.

LAUNCHING PAYLOADS ON A SHOESTRING

Engineers at NASA have pioneered a new way to propel spacecraft through space, using a surprisingly low-tech approach: tethers.

In a recent experiment, a 57-pound aluminum box was launched at the end of a 12.4-mile-long synthetic cord no thicker than kite string. After the cord unwound at 450 miles up, it was severed, hurling the box to Earth along a precise course. It disintegrated in the atmosphere off the west coast of Mexico.

Known as the Small Expendable Deployer System (SEDS), the experimental device demonstrated that engineers could aim a payload with a tether, says project director Jim Harrison of the Marshall Space Flight Center in Huntsville, Ala. Future payloads, even space shuttles, might be lowered to Earth from a space station using a similar technique.

NASA hopes tethers can someday replace expensive booster rockets to propel satellites into higher orbits or cast probes across the solar system. Rockets still would be necessary to overcome Earth's gravity and reach orbit, but once in orbit, a tethered object could be moved about according to a concept that is as simple as a child's sling.

The $10 million SEDS experiment, launched in March, rode to orbit on a Delta II rocket whose primary mission was the deployment of a military navigation satellite. The aluminum box and the spool of cord were bolted onto the rocket's second-stage booster, which was jettisoned and remained orbiting Earth at a speed of 18,000 mph. Springs popped the box free, and its outward momentum unwound the cord, which is made of Spectra—a high-strength, polyethylene material used in bulletproof vests and kite string. A brake slowed the tether as it was close to fully unwinding. Then, with the payload swinging like a pendulum, a blade cut the cord at a predetermined moment, slinging the box along the proper trajectory.

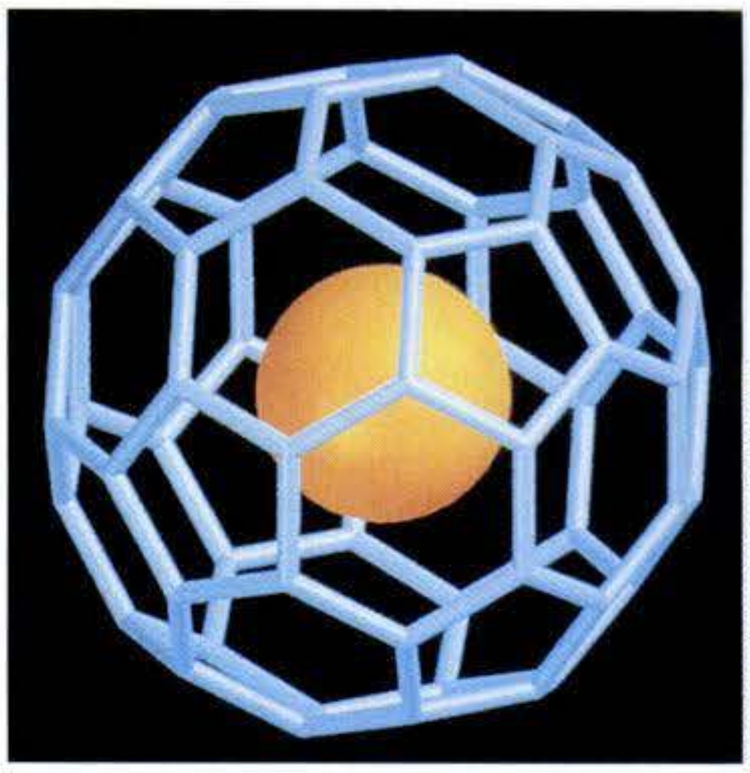
In coming months, NASA will use a tether to loft a small ham-radio satellite, adding some 300 miles to its orbit.—*David Graham*

MOLECULES

NEON BUCKYBALLS

Chemists at Yale University have discovered a "window" in buckminsterfullerenes, or buckyballs, the all-carbon molecules shaped like soccer balls ["Buckyball: The Magic Molecule," Aug. '91]. By forcing an atom of neon through the window opening, a team led by chemist Martin Saunders has created the first neon compound ever known. The chemists can perform the same trick with helium.

Until this discovery, scientists did not believe that stable compounds of neon or helium could exist. But Saunders and his colleagues demonstrated that a gas such as neon can be incorporated in buckyballs by heating the carbon molecules to at least 600°C in the presence of the gas. The heat apparently breaks one of the bonds linking adjacent atoms in the buckyball, and a neon or helium atom can pass through the opening to enter the hollow center of the molecule. When the temperature falls, the window closes, and the gas atom is trapped inside the carbon cage.



MARTIN SAUNDERS/YALE UNIVERSITY

This carbon buckyball with a neon atom inside is the first stable neon compound ever identified.

Saunders says buckyballs filled with radioactive tracers could be used to track ocean currents or, by adding a tracer tag to each oil shipment, catch polluters responsible for oil spills. For example, buckyballs could be filled with a rare helium isotope that can be detected in very small concentrations. "If one microgram of the helium-doped buckyballs were dissolved in an Olympic-size swimming pool and the water was thoroughly stirred," says Saunders, "we could measure the helium from the buckyballs using only a single drop of water."

MEDICINE

NO NEEDLES NEEDED

If you look up at a clear, blue sky, you can see what look like tiny shooting stars. They're actually white blood cells crossing your retina. A healthy person sees too many cells to count. But an anemic person, such as an AIDS patient, can estimate his own white blood cell count by comparing what he sees with color plates showing varying degrees of star density. Researchers from Northwestern University and Rush-Presbyterian-St. Luke's Medical Center in Chicago who developed the method say it could educe the number of blood samples that must be drawn from patients.

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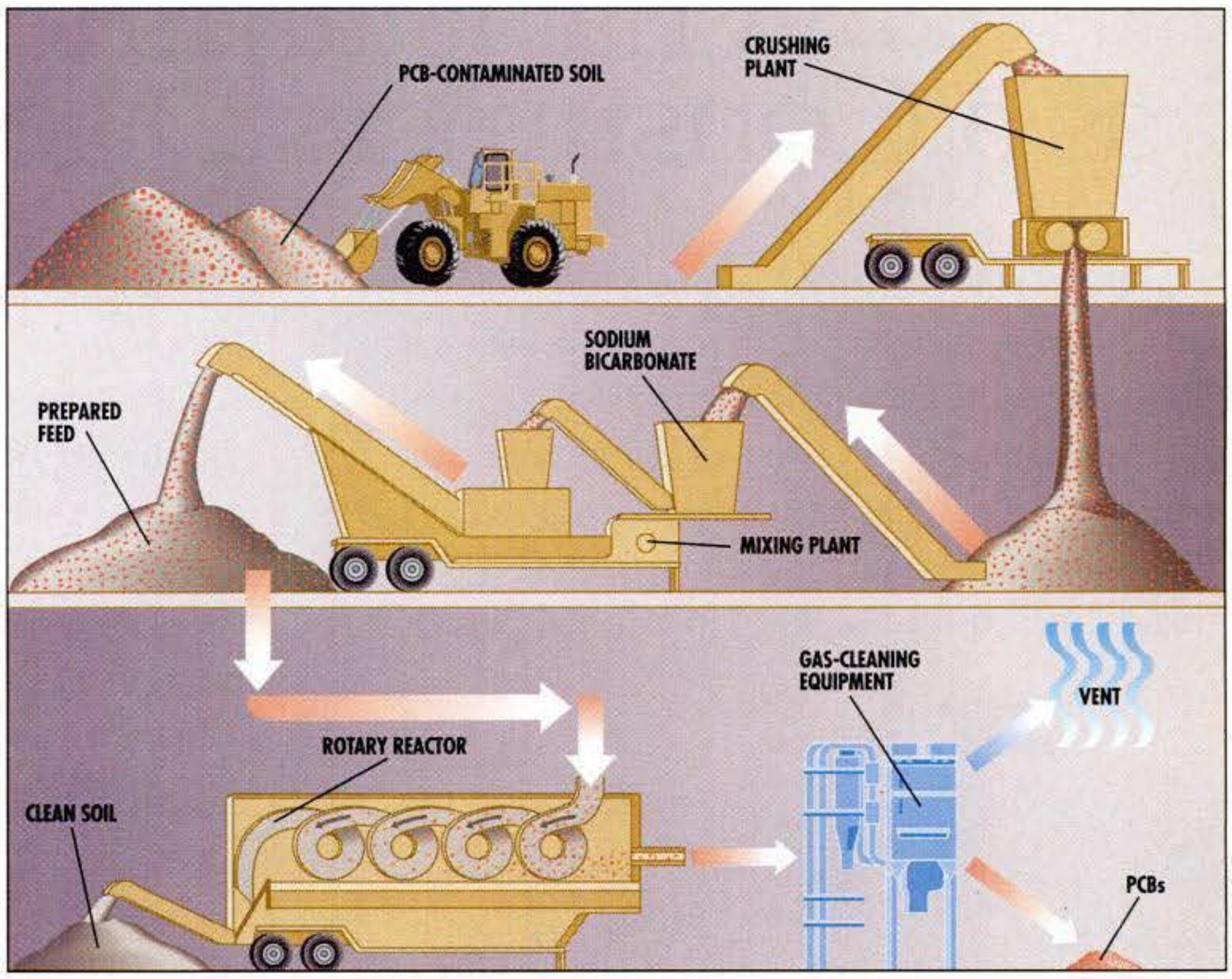
WEATHER

STAIRWAY TO THE SKY

Storm clouds store tremendous amounts of electricity, but what causes the spectacular short circuit we call lightning? Atmospheric scientists have long puzzled over the mechanism that initiates lightning and have never understood why lightning strikes in a zigzag path.

Now Los Alamos National Laboratory plasma physicist Robert Roussel-Dupré and his collaborators—Alex Gurevich of Moscow's Lebedev Institute of Physics, Genady Milikh of the University of Maryland, and Tom Tunnell of EG&G Energy Measurements—have proposed a cosmic ray theory that could explain the mechanism that sparks lightning and also its distinctive pattern.

Cosmic rays are high-energy protons and other particles from space that continually bombard Earth. According to the new theory, cosmic rays that collide with air molecules knock off electrons and send them downward at high speed. Propelled along by the electrical field within a thunderstorm, the electrons collide with additional air molecules to create a cascade of electrons. These electrons pool up at the base of a storm cloud. Then, millionths of a second later, cosmic rays knock another electron off an air molecule. The electrons pooled at the cloud's base accelerate the new electron downward to create a second cascade. The result: A series of ionized pathways advances to the ground, and lightning soon crashes toward Earth in zigzags.—*Ray Nelson*



Mixed with sodium bicarbonate, one metric ton of PCB-tainted soil can be cleansed per hour in a rotary reactor. The PCB-treatment technology is an alternative to incineration.

POLLUTION

RECIPE FOR PCB DESTRUCTION: ADD BAKING SODA

Somehow the United States has to clean up the hazardous PCBs that taint an estimated 900 million metric tons of soil. But incineration, the most common treatment, can be costly, risky, and unpopular. It's enough to give officials an upset stomach. The cure? Sodium bicarbonate, say researchers at Battelle's Pacific Northwest Laboratories in Richland, Wash. The well-known antacid can detoxify PCBs for one-fourth the cost of incineration.

PCBs, or polychlorinated biphenyls, are long-lasting industrial chemicals once used in transformers and lubricants. Production was banned in 1976 after they were linked to cancer.

In the Base Catalyzed Destruction process developed by the EPA with Navy funding, Battelle researchers blend small amounts of sodium bicarbonate—commonly known as baking soda—with contaminated soil. The mix is heated to 350°C in a rotary reactor.

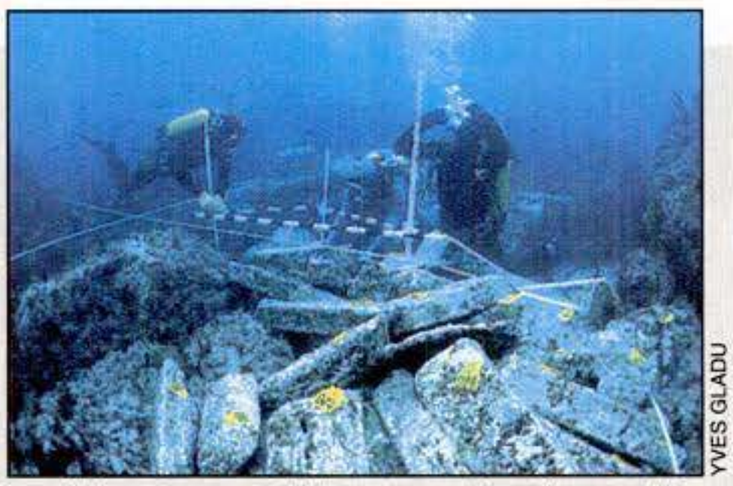
Hydrogen from the sodium bicarbonate replaces chlorine and other halogen molecules in the PCBs. The result is soil that contains less than two parts per million (ppm) of PCBs (far less than the EPA's 50 ppm limit), some sodium chloride (salt), and a nontoxic biphenyl. Conventional gas-cleaning equipment handles emissions.

In comparison, incineration requires expensive higher-temperature combustors to destroy PCBs, and it produces emissions that can contain trace amounts of carcinogenic dioxins.

The new treatment system is portable. In addition to PCBs, it can handle dioxins, pesticides, and other hazardous organic compounds. After completion of a pilot program, researchers will conduct a larger-scale test at a Navy site in Guam.—*M. D.* PS

DARK MATTER

OLD METAL AIDS SEARCH


YVES GLADU

Lead bars recovered from a sunken ship could help scientists detect the "missing mass."

In their search for "dark" matter, French astrophysicists are using lead bars found in a Roman ship sunk more than 15 centuries ago off the coast of Great Britain. According to the big-bang theory, most of the mass of the universe consists of dark matter, which is invisible. The detection of dark matter, which exerts a gravitational pull, would provide scientists with evidence that the universe will eventually cease expanding.

Bolometers, instruments used to detect subatomic particles of dark matter, must be shielded from radiation to be effective. Even the extremely small traces of radiation emitted by a laboratory lamp can hamper the detection of particles that collide with the bolometers.

In a French underground laboratory in the Alps, the bolometers are first shielded from cosmic rays by 1,780 meters of rock. For protection against the traces of radiation emitted by the rocks themselves, the bolometers are placed inside a box made of the Roman lead, which emits far less radiation than today's lead. Once it is mined, the ore used to make lead is no longer exposed to radioactive elements in the surrounding rock, so its radioactivity drops off over time.—*Bruce Gain*

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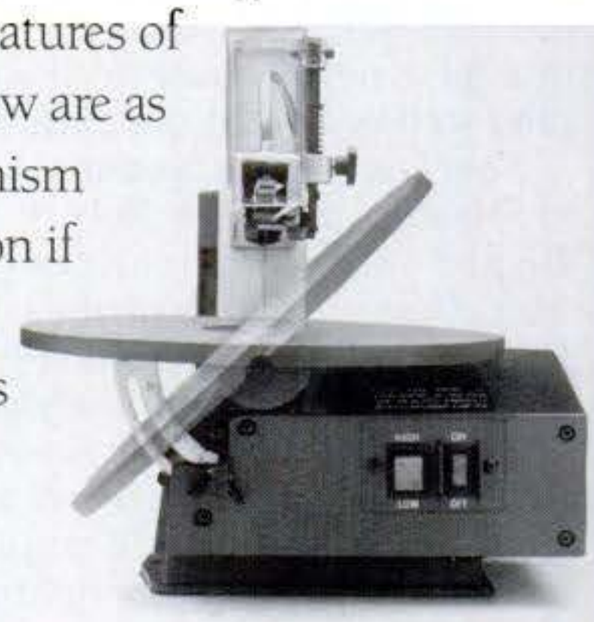
What it takes to cut it as a Consumers Digest Best Buy.

You don't get named a *Consumers Digest* Best Buy without working at it. You have to be an *outstanding* value. That's the Dremel 1671 Scroll Saw.

The Dremel 1671 has a lot of features that make it a pleasure to use. It has two cutting speeds and a powerful motor that lets you buzz through wood up to two inches thick, as well as sheet metals and plastics.

The sturdy, 12-inch cast aluminum table is adjustable from 0° to 45° for accurate bevel cuts up to 1-inch thick.

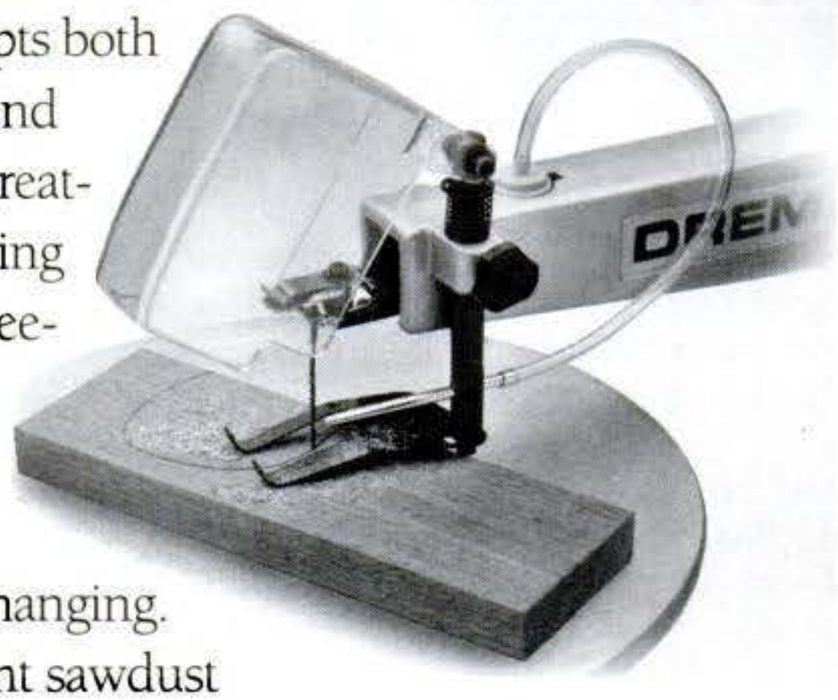
Of course, not all the features of the Dremel 1671 Scroll Saw are as obvious. A special mechanism quickly stops cutting action if the blade breaks. And the heavy cast-iron base keeps vibration to a minimum.



So if you're searching for the perfect scroll saw for your craft or other woodworking projects, check out the Dremel 1671.

A 16-inch throat and the ability to cut from both the front and the side, means you can handle large work pieces.

The saw accepts both plain- and pin-end blades, for the greatest possible cutting versatility. The see-through blade guard pivots out of the way for easy blade changing. And a convenient sawdust blower keeps your cutting line clear for accurate cuts.



And see why *Consumers Digest* placed it a cut above the rest.

For a free copy of the *Dremel Scroll Saw Blade Application Guide* write to: Dremel, Dept. S-PS, P.O. Box 1468, Racine, WI 53406-1468.

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AUTOMOTIVE

EDITED BY DAN McCOSH

ENGINE TECHNOLOGY

MAZDA MEETS MILLER

Mazda claims to have leapt ahead of turbocharged performance and lean-burn efficiency in a single bound with a Miller-cycle engine, a variation of the conventional four-stroke Otto-cycle combustion process that is the basis for most passenger car engines today. Mazda says the engine delivers 50 percent greater torque than a conventional four-stroke engine of the same displacement while improving fuel efficiency 10 to 15 percent.

The benefit of the Miller cycle is that it lowers the compression ratio of a supercharged four-cycle engine to prevent engine knock, while retaining the normal expansion ratio (the ratio between the volume of the cylinder with the piston at top dead center and the volume at the bottom of its stroke).

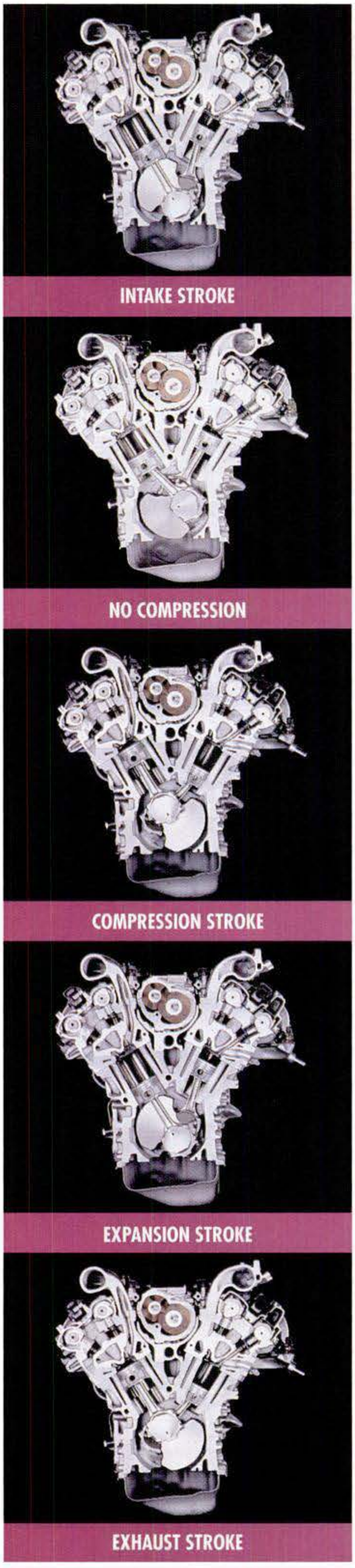
Supercharging typically increases engine torque in proportion to the amount of intake air. But supercharging also can result in engine knock because of premature combustion. Lowering the compression ratio is the usual solution, but that results in a lowered expansion ratio and decreased efficiency.

In the Miller cycle, a positive-displacement supercharger forces air into the cylinder while the intake valve is held open until the piston is one-fifth of the way up from bottom center—creating, in effect, a shortened compression stroke. The screw-type supercharger provides additional air, so that when the intake valve does close, the cylinder of Mazda's new engine still has about twice as much air as a conventionally charged cylinder, despite the shortened compression stroke, while the full expansion ratio is maintained.

Conceived of by American Ralph Miller in 1947, Miller-cycle engines have been used in ships and power generators. Kouichi Hatamura, who led the development of the engine for Mazda, says that adapting the technology for cars requires a compact, high-efficiency air compressor—conventional turbochargers and superchargers just can't generate the volume of air required.

Mazda teamed with heavy equipment manufacturer Ishikawajima-Harima Heavy Industries Co. to develop a belt-driven, screw-type compressor supercharger. The new supercharger is expensive, which is one reason Mazda doesn't plan to use the Miller-cycle engine in small cars. Lean-burn technology makes more sense there, according to the company. Mazda is also working on applying the Miller cycle to rotary engines.

The engine will be mounted in a new production car "in the near future." Bets are it will be unveiled at the Tokyo Motor Show in the fall. —*Dennis Normile*



The Miller-cycle engine shortens the compression stroke, while leaving the expansion stroke intact—improving torque and fuel economy without preignition.

ELECTRONICS

MAKING YAW A YAWN

Picture entering a slippery corner and feeling the beginning of a dangerous skid when the throttle automatically cuts back, and each individual wheel brake on the car begins to modulate itself until the skid is corrected and the car is back under control. The ability to control a vehicle's yaw rate—the slip angle of its wheels during cornering—should be one of the next major frontiers in improved automotive safety.

On-board yaw-control systems are being developed by a number of automotive suppliers, and GM's Corvette Group is among those encouraged by early yaw-control system tests. Robert Bosch, the German electronics and antilock brake system giant, is nearing production on what it calls VDC—Vehicle Dynamics Control. Its competitor, ITT Teves, is also working on a similar system.

According to Dr. Norbert Rittmannsberger, head of Bosch's ABS, Chassis and Safety Systems Division, the heart of VDC is a chassis-mounted computer, which gets its inputs from the vehicle's ABS wheel-speed, traction-control, and steering-angle sensors, as well as the engine controller. Using these signals, the chassis computer constantly compares the vehicle's real-time directional travel with a program of "ideal" strategies; it gives self-corrective action (including throttle and brake control) if the driver enters a spin.

Look for VDC to enter the production stage in 1995 or 1996, says Rittmannsberger.—*Lindsay Brooke*

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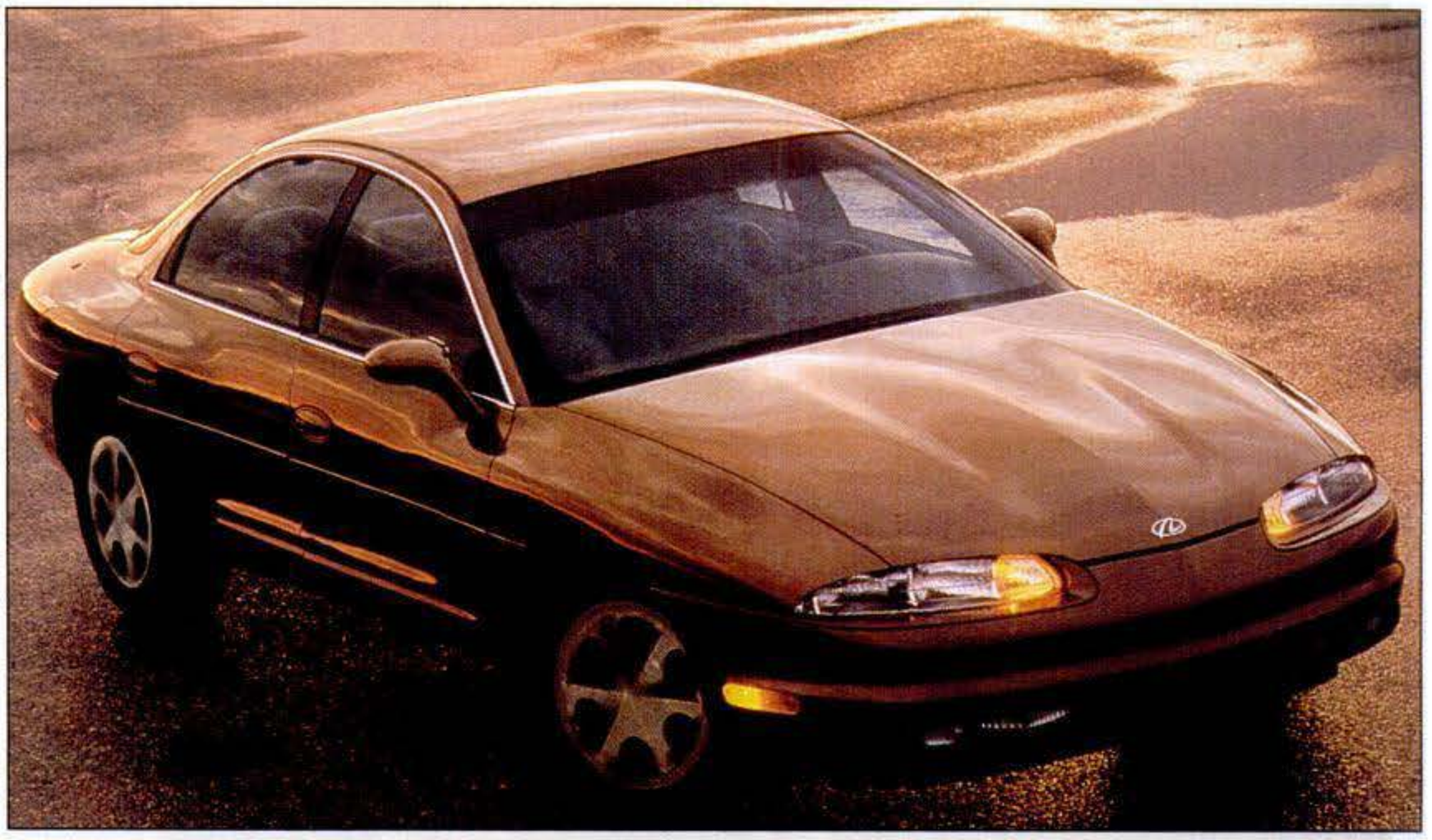
1995 MODELS

THIS IS REALLY NOT YOUR FATHER'S OLDSMOBILE



Aurora's sleek lines net the four-door sedan a 0.32 coefficient of drag. Exterior chrome trim is minimized.

BY RICHARD STEPLER

In fact, nowhere on the striking curves of this sedan will you find a badge that says Oldsmobile. When it's introduced in the spring of 1994 as a '95 model, you'll see only the Aurora name—inside and out. The car even eschews Old's rocket symbol, using a stylized A instead. Only the face of the radio says Oldsmobile, and, of course, you'll only be able to buy the car at Oldsmobile dealers.

For looks nonwithstanding, Aurora is indeed an Oldsmobile, perhaps the most troubled of GM's divisions. Olds hopes to end its recent sales decline with this new flogship, competing with the likes of Acura, Infiniti, and Lexus. "Aurora is a no-excuse car," says Oldsmobile's Brian Kearney. "We want to do to the Japanese what the Japanese did to the Germans."

The overall length of Aurora is 205.4 inches, riding on a 113.8-inch wheelbase. By comparison, the Olds 98 is 205.5 inches long, with a 110.7-inch wheelbase. Aurora's price tag? About $32,000.

What do you get for that kind of money? Aurora's features are pretty much state of the art. Power comes from a four-liter, 32-valve double-overhead-cam V8 that produces 250 hp at 5,600 rpm and 260 lb.-ft. of torque at 4,000 rpm. The service life of the engine's platinum-tipped spark plugs is 100,000 miles. In the event of coolant loss, the engine has a "limp-home" mode that cuts fuel delivery to four cylinders, with the remaining four providing power for a 50-mph top speed. The four non-firing cylinders pump enough air to prevent engine damage from overheating.

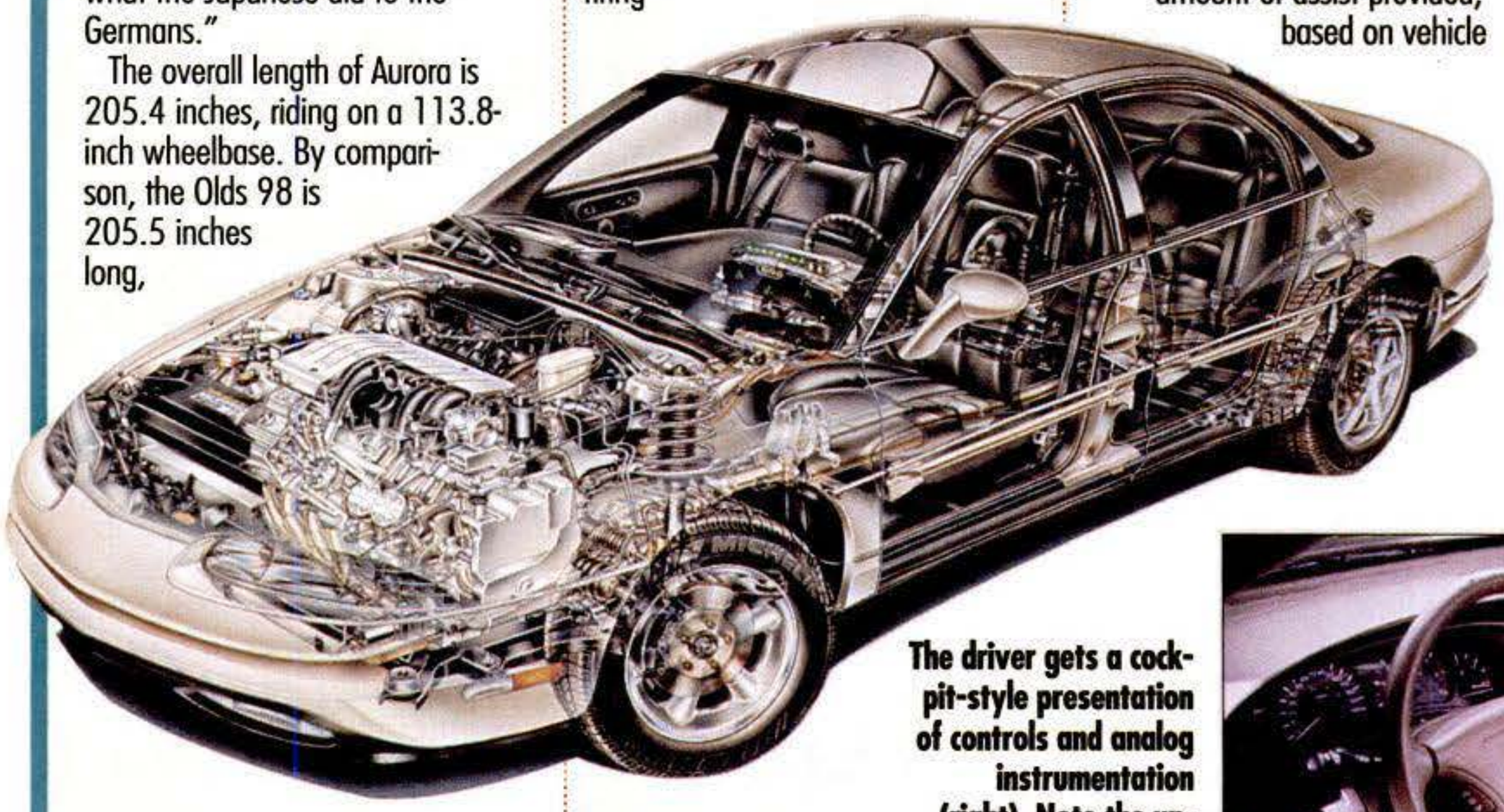
The transverse-mounted V8 drives the front wheels via equal-length half shafts that effectively eliminate torque steer. The transmission is an electronically controlled four-speed automatic with driver-selectable normal and performance modes. The suspension is independent, front and rear. In the front there's a modified Macpherson strut, while the rear is a semi-trailing arm design.

Aurora's power steering has a unique twist: It uses a permanent magnet to vary infinitely the amount of assist provided, based on vehicle speed. The advantage is that the change in assist rate is transparent to the driver.

In test drives, I found that it all works as advertised, even in aggressive driving maneuvers. Aurora corners flat, with precise steering, and in hard braking the car shows little dive. Steering effort in the prototypes I drove seemed too high at low speeds, but this will be corrected on production models. On the road, the high, 25-hertz natural frequency of Aurora's body structure gives the car a solid feel.

Safety systems include disc brakes on all four wheels, with a Teves anti-lock system, plus a full-speed Teves traction-control system. Unlike low-speed traction-control systems that typically function at speeds below 25 mph, Aurora's system sends more power to the wheel with the most grip at speeds up to 138 mph.

There are driver- and passenger-side air bags, adjustable three-point seat belts, and well-supported seats for four passengers. PS



The driver gets a cockpit-style presentation of controls and analog instrumentation (right). Note the under-the-rear-seat location of the battery and the above-the-rear-axle nylon gas tank.

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NAME CHANGES

HONDAUZU?

Isuzu and Honda are working out an arrangement for Honda to sell Isuzu's mid-range Rodeo model in the United States. The vehicle won't be changed much, aside from an anointment with the Honda badge and new model name.

Rodeos are assembled at the Subaru-Isuzu America plant in Lafayette, Ind., which will be able to supply 20,000 relabeled Rodeos during 1994.

The move reflects belt-tightening in the Japanese automotive industry. Isuzu has decided to stop building cars and concentrate on trucks. Honda benefits by adding a four-wheeler to its lineup without investing in developing a homegrown truck.

All but the entry-level version of Isuzu's Rodeo have been upgraded for 1993 with the 175-hp, single-cam V6 engine found in the base-model Trooper. The power plant replaces a slightly smaller one built by General Motors. —*Stuart F. Brown*

NAVIGATION

DON'T TOUCH THAT DIAL

You won't be completely free to keep your eyes on the road but you will be able to keep your hands on the wheel using a new Sanyo Electric Co. navigation system that responds to spoken commands.

As with other navigation systems, the destination must be input by manual selection from a map or a menu. The system automatically selects a route and displays it on a map. At this point, voice recognition allows the user to verbally ask for a more detailed map or a map showing either the destination area or the present location.

In all, the system recognizes 14 commands, including commands to switch to a CD player or television. The system can only handle one user, who must input his or her voice by speaking each of the 14 commands once.

Other voice-control or voice-input features may be added to match advances in voice-recognition technology. A navigation system including the voice-recognition feature went on sale in Japan this spring for $2,740. A four-inch liquid-crystal display with TV tuner is sold separately for $1,480.

The system is not currently available in the United States. Sales depend on the availability of digitized maps.—*D. N.*

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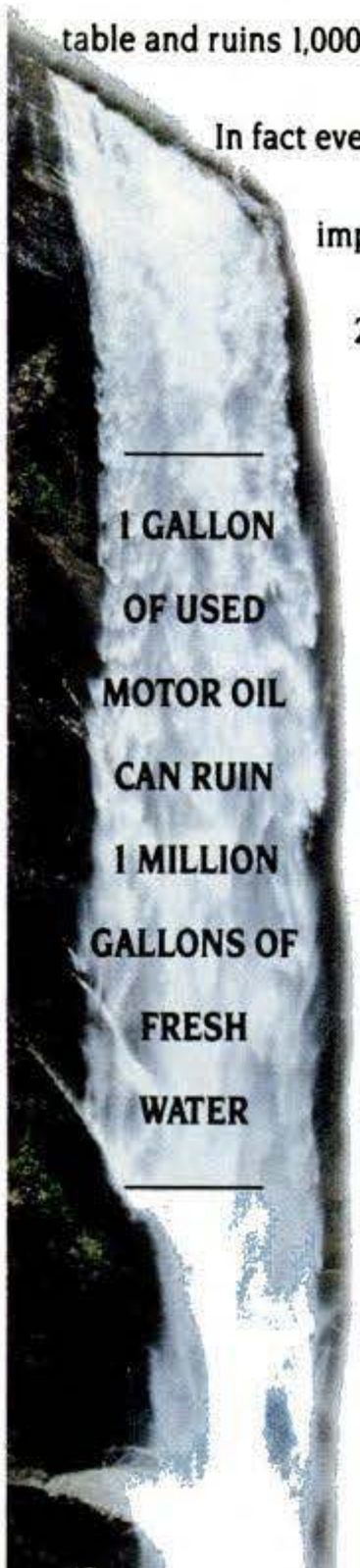
PEOPLE WHO KNOW RECYCLE™

When you dump the used motor oil from a single oil change in the trash, pour it on the ground, or toss it into the sewer, it seeps down into the water table and ruins 1,000,000 gallons of fresh water.



In fact every year "do-it-yourselfers" improperly dispose of 220,000,000 gallons of used motor oil. That's why Valvoline Environmental Services is so important.

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PREVIEW DRIVE

JOHN B. CARNETT

The new Acura Integra coupe (above) features distinctive elliptical-projection headlamps (inset).

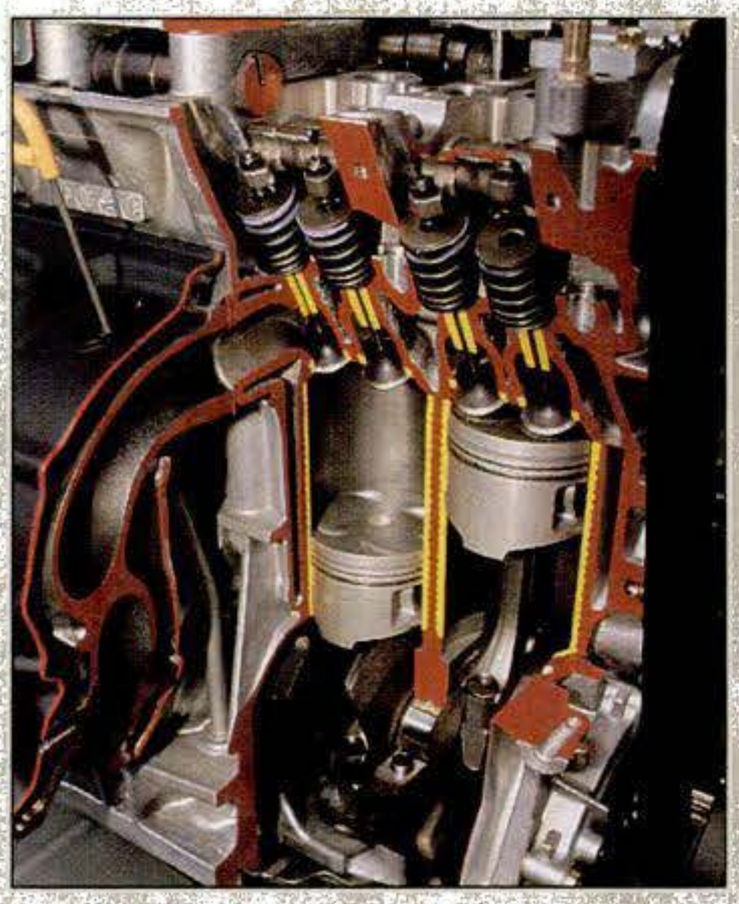
HIGH-TECH INTEGRA

Honda's relentless pursuit of superior engine technology, even for its low-priced lines, may have reached a pinnacle in the 1994 Acura Integra.

The 103.1-inch-wheelbase Integra, with a base price of roughly $18,000 to $19,000, can be viewed as either a pricey small car or one of the more diminutive luxury cars. In any case, it is an unpretentious passenger package offered as either a modestly luxurious four-passenger sedan or an aggressively styled two-plus-two coupe. Four elliptical-projection headlamps, each the approximate diameter of an orange juice can, give the front end a distinctive look.

But what sets the Integra apart is Honda engineers' deliberate effort to eschew the trend toward relatively large V6 power plants in favor of stretching the potential of a relatively small-displacement 1.8-liter four-cylinder engine.

In the double-overhead-cam VTEC version, which generates 170 hp at 7,600 rpm, the Integra engine produces 94.4 hp per liter, respectable for a non-turbocharged racing engine a few years ago. The long-stroke design with a phenomenal 8,000-rpm redline prompts Honda engineers to claim the highest piston speed in the world for a mass-production engine.



The VTEC engine is a long-stroke, high-revving, highly efficient design.

Since high piston speed, in the real world, is normally inverse to long life, the source of this pride is intriguing. As it turns out, the confidence comes from the use of an unusual bearing material originally developed for Honda's now-defunct Formula 1 effort. The bearing material, based on a new crystalline structure for the zinc alloy used in the Formula 1, is created by precise control of the current in the plating process. The material has a microscopic structure of tiny pyramid-shaped molecules, which retain oil at high speeds, extending bearing life by as much as 35 percent, according to Honda.

The new bearing material allows a rush of gains—narrower bearings, a shorter crankshaft, a stiffer engine, higher rpm, lower friction, and higher output.

Despite the high power peak, Honda's third-generation VTEC variable-phase valve system makes the engine eminently drivable. The VTEC system uses an ingenious double-lobe cam that provides two distinct valve actuation curves. For the new engine, a double intake runner is added, and the valve-phase actuation point is lowered. The result is a virtually flat torque curve. How flat? For a drive on Honda's Tochigi road course, two gears are adequate for most of the course, pulling from just over 2,000 rpm to the weird, silky-smooth 8,000-rpm redline.

The automatic transmission, long a Honda weak point, is now smoothed out with fuzzy logic, and the power-steering gear finally is linear and positive. The added travel of the suspension soaks up bumps, but suspension tweaks improve handling. Finally, Honda stiffens the linkage on its manual gearshift, improving what already was one of the smoothest shift linkages in the world.

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MOTORCYCLES

BRITTEN'S BREAKTHROUGH

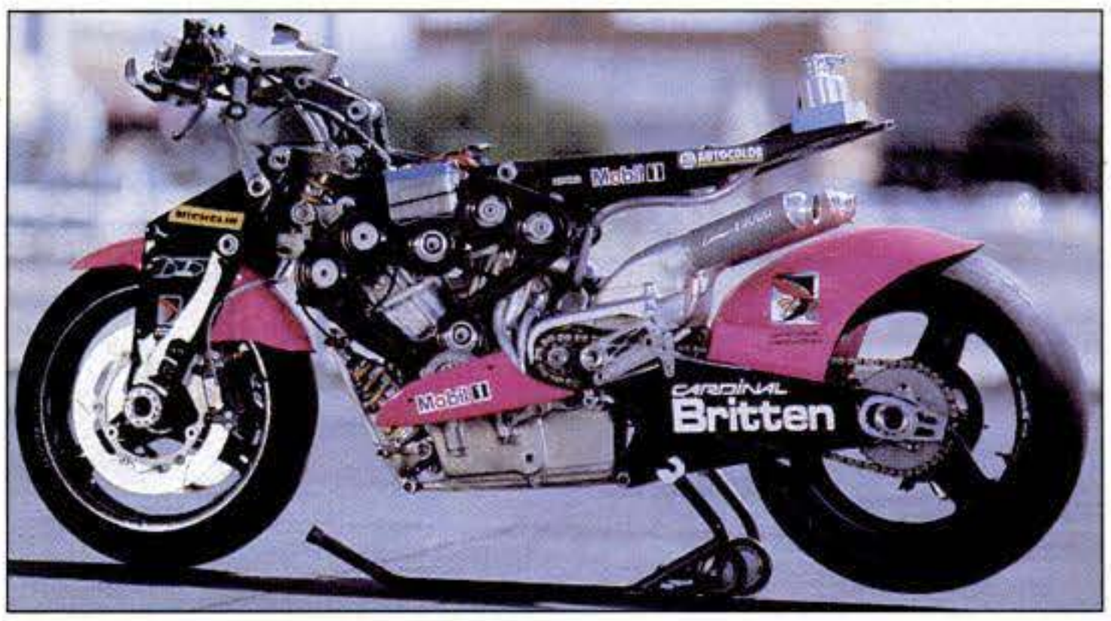
If you were part of an engineering team at a major motorcycle manufacturer, you might feel a bit intimidated by what John Britten of Christchurch, New Zealand, has done —by himself.

Britten's hand-fabricated Daytona V-1100 is a brilliantly unorthodox racing bike. Dramatically frameless in its construction, the machine's components are all hung directly onto the engine, an aluminum V-twin of either 1,000-cc or 1,100-cc displacement. The rear suspension uses a swing arm pivoting on the rear of the engine casting to actuate, through a linkage, a shock absorber nested in the front of the engine. The front-suspension arrangement, which Britten calls a double-wishbone girder, remains supple during hard braking—overcoming a shortcoming of familiar telescopic forks.

A patent is pending on the "skin and bones" method Britten developed for fabricating the swing arm, fork girders, wheels, and seat-supporting subframe from a mixture of carbon-fiber and Kevlar by winding filaments tightly around grooved spools, then adding sheets of woven carbon fabric.

The inventor designed, cast, and machined the entire engine except for ultralight pistons borrowed from a Formula One racing-car engine. Pairs of custom-designed fuel injectors nourish the cylinders, which use a sky-high 13.7:1 compression ratio. A serpentine belt drives twin overhead camshafts opening four valves per cylinder. At 9,500 rpm, the V-1100 racing engine develops 170 hp and massive amounts of torque. With a weight of only 303 pounds, it's a potent competitor that, in its 155-hp, 1,000-cc version, has won the last 20 consecutive races it has entered in New Zealand.

Motorcycle mavens with $75,000 to invest can order one of the two remaining road-going racer-replicas, with muffled 1,000-cc engines and electric starters, among the ten that are being hand-built. So far, eight enthusiasts have voted with their wallets for Britten's singular vision of what a motorcycle should be.—*S. F. B.*



Everything centers around the minimalist Britten racer's fierce and narrow engine, which uses featherweight titanium valves and connecting rods.

MINICARS

TODAY'S TODAY

Honda's Today is one of those Japanese minicars that sometimes begin and end a discussion on how far the search for fuel economy can take you. The car is a byproduct of Japanese licensing restrictions that encourage development of cars with engines displacing less than 750 cc and with diminutive chassis and bodies that fit neatly on narrow Tokyo streets.

The Today was redesigned this year to incorporate a longer nose, side-door intrusion beams, and a less flammable interior—all improvements that address a growing demand for safety features in Japanese cars. The Xi version uses a 656-cc, three-cylinder, SOHC engine that produces roughly 58 hp at 7,300 rpm. The 90-inch-wheelbase car thus is strongly reminiscent of the first Honda 600s, which were once imported.

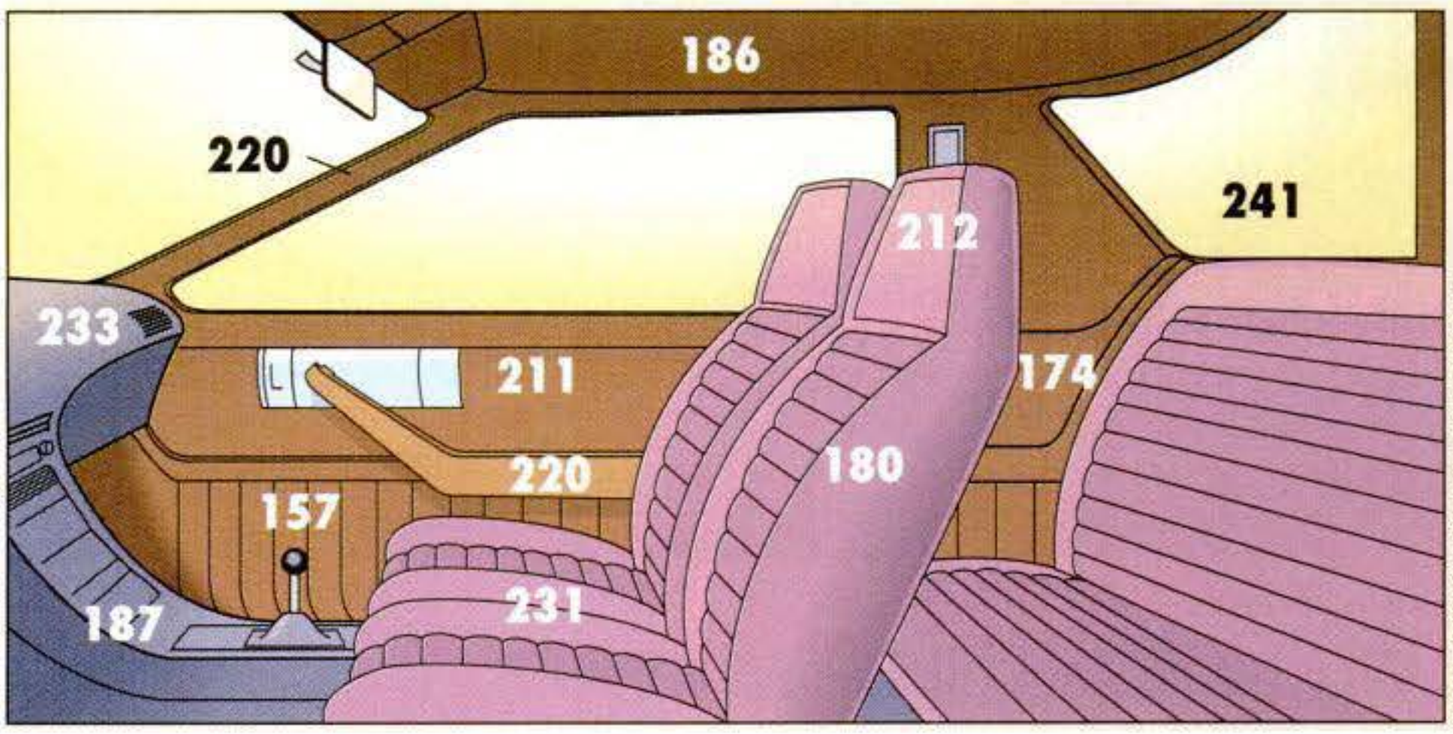
A short test drive reveals that the tiny sedan has more potential for fun than for performance or utility. And combined with a price of about $9,000 for the Xi version, the Today is an unlikely candidate for export.

Honda's new Today is safer and more stylish, but still expensive.

INTERIORS

HOW HOT WAS IT?

The interior of a car parked in the sun with the windows closed can get awfully hot. Exactly how hot? Take a look at the temperature chart below, which assumes an ambient temperature of 105°F. All temperatures are in degrees Fahrenheit.



ALTERNATIVE FUELS

CHEAPER THAN GAS?

Scarce as they are, alternative, pollution-reducing fuels are slowly becoming available to the driving public, particularly in areas like Los Angeles, where their use in corporate fleets is being mandated.

According to Runzheimer International, which surveys gasoline prices nationally, the comparable prices per gallon of gasoline, liquid propane gas (LPG), compressed natural gas (CNG), and 85 percent methanol are $1.26, $1.23, $.73, and $.86, respectively. Energy content changes the picture considerably, however: LPG has only 71 percent the Btu content of gasoline, compared with 17 percent for CNG and 60 percent for methanol. PS

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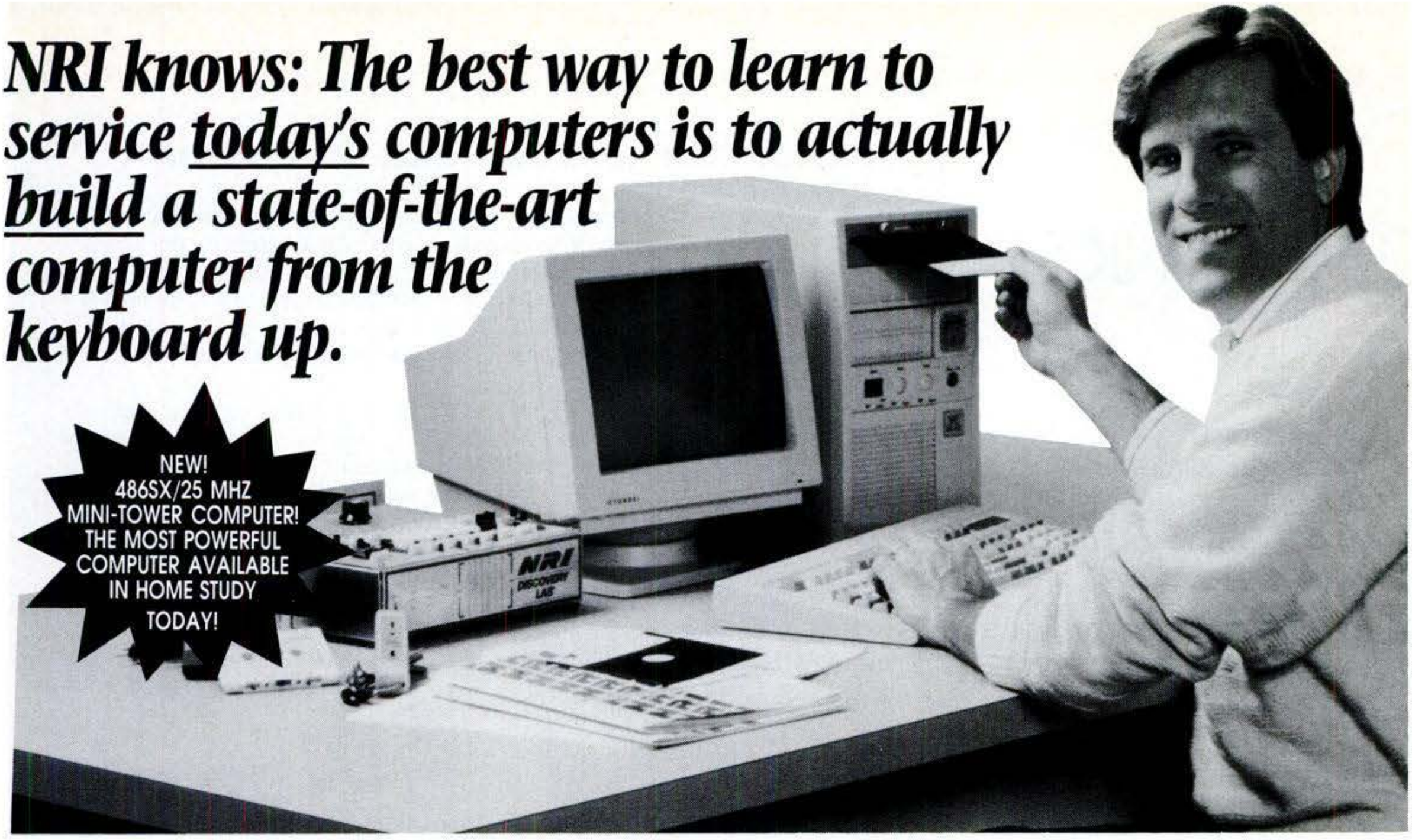

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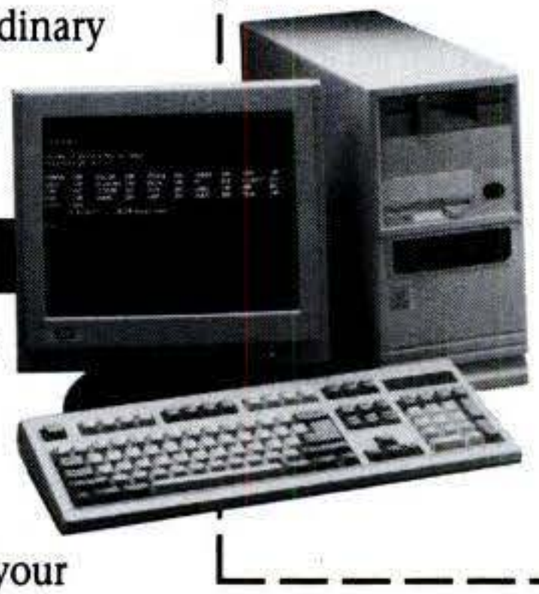

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ELECTRONICS

EDITED BY MICHAEL ANTONOFF

X-RAYS

A SHARPER IMAGE

A new kind of X-ray device that detects details conventional systems miss is attracting the attention of aeronautical and medical organizations. Invented by Richard Albert, now president of Digiray Corp. of San Ramon, Calif., Reverse Geometry X-ray (RGX) produces vivid X-ray images on a computer screen nearly instantly in two or three dimensions.

McClellan Air Force Base is using RGX to inspect damage and repairs on the radar-thwarting skins of its F-117 stealth fighters. NASA also has purchased one of the $200,000 machines to be used as a corrosion-detection tool in its revitalization program for aging aircraft. And the Federal Aviation Administration is interested in RGX to detect plastic explosives and composite and plastic handguns in luggage.

The RGX process boosts image clarity by improving on X-ray system design. With conventional X-ray systems, rays emit from a small point and fan out toward the specified object, which is located some distance away in front of a large X-ray detector housing the film. Image fuzziness occurs because some X-rays scatter when passing through the object or bounce off the detector. With RGX, the process is reversed. The object is placed close to a much larger scanning X-ray source, and a small detector is further away.

STEVE STANKIEWICZ

Conventional X-rays scatter (top), resulting in a fuzzy image. With Reverse Geometry X-ray (bottom), fewer rays bounce off the detector or enter the narrow receiving field, reducing fuzziness. An RGX image (inset) shows a plastic Glock gun above a metal pistol.

Instead of film, the detector contains tiny crystals that light up when excited by X-ray beams, creating an image. A computer processes the image into a digital X-ray. RGX greatly reduces fuzziness because errant beams are less likely to enter the narrower receiving field of the small detector.

For three-dimensional imaging, Digiray mounts several detectors in tandem; a computer overlays the images. Colorization helps isolate elements visually and a zoom-type feature makes it possible to locate, for example, a small crack in an engine block or circuits in a computer chip.

Because RGX reveals tendons and muscles, its potential medical uses are enormous. A 3-D CAT scan device is planned. —*Scot Finnie*

PHOTOGRAPHY

GIANT CCD CHALLENGES FILM ON RESOLUTION

Will electronic cameras ever replace film-based photography? It's been predicted that amateurs will eventually flock to filmless cameras as prices begin to tumble, but that professionals will continue to use film for years to come. The main reason experts don't expect the pros to use filmless cameras is the quality of the photographs these cameras take. At the heart of a filmless camera is a charged coupling device (CCD), which now is capable of capturing a total of 1.5 million pixels of visual data. By comparison, Kodachrome film has the silver halide equivalent of 18 million pixels.

Recently, though, Dalsa Inc. of Waterloo, Ont., announced a major breakthrough in CCD technology with the introduction of a monster-size 2.5-square-inch chip called the Megasensor. (The average CCD in a good-quality camcorder is about the size of a dime.) Packed on the chip are 26.2 million pixels, which give it one-third better resolution than Kodachrome film. Dalsa will initially price the Megasensor at $20,000 to $50,000 per chip. Although not competitive with film at that price, the Megasensor could eventually be used to produce film-quality digital motion pictures for theatrical release. It could also have medical, military, and scientific applications. —*Daniel Grotta*

The Megasensor CCD (far left) dwarfs HDTV (near left) and conventional TV (below) devices.

VIDEO GAMES

FAMILY VALUES?

As video games and television programs become more violent and risqué, efforts are growing to allow parents to filter out objectionable broadcasts electronically or at least provide guidance via a rating system.

This month, Sega will add ratings to its nearly 400 Genesis games and CD titles. Purchasers can choose from GA (general audiences), MA-13 (for more mature audiences), and MA-17 (adults only). Sega took action after the Toys R Us chain banned its Night Trap game from stores in Britain and Canada. In the game, players work to save scantily clad women from a serial killer.

Nintendo, meanwhile, has rejected such ratings, calling them an excuse for not deciding beforehand what is acceptable in a video game.

Parents could lock out violent TV programs if an idea from Rep. Edward Markey ever comes to pass. While there is no formal proposal, the chairman of the House Energy and Commerce subcommittee has suggested that manufacturers be required to build an anti-sex-and-violence control chip into new sets.

One way such a filter might work would be through a data stream in the transmission signal with a code that indicated program ratings. The chip could then block reception of objectionable programming.—*Mariette DiChristina*

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HDTV

Rivals Agree To Merge Systems

Proponents of several technologies vying to become the standard for high-definition television (HDTV) in the United States have agreed to a unified system. The compromise seeks to accommodate the competing needs of TV manufacturers, broadcasters, and computer makers.

The Federal Communications Commission's Advisory Committee on Advanced Television Service will now review a single digital system proposed by a "Grand Alliance" of companies and organizations including AT&T, the David Sarnoff Research Center, General Instrument, North American Philips, Thomson Consumer Electronics, and Zenith Electronics.

The Benefits Of HDTV

- WIDE-SCREEN PICTURE
- MOVIE-QUALITY RESOLUTION
- COMPACT DISCLIKE SOUND
- COMPATIBILITY WITH COMPUTERS

The alliance's technical proposal embraces employment of progressive-scan transmission (in which entire picture frames are transmitted sequentially) and the use of square pixels (in which the dots on a television screen are arranged in equally spaced rows and columns). Both of these design aspects are important for the interoperability of HDTV with computers. Interlaced-scan transmission, used in TV today, would be accommodated initially for smaller TVs.

The backers agreed that all HDTV receivers that measure 34 inches diagonally or more will incorporate sets capable of displaying 60 frames per second and 787.5-line resolution or higher in progressive-scan mode. All film material will be transmitted in that scan format from the outset. The alliance endorsed the objective of increasing progressive-scan transmissions to at least 1,000 lines as soon as possible and to eventually eliminate interlaced scanning entirely. A data-compression scheme known as MPEG-2 will be used.

If the FCC approves the plan this year, regular HDTV broadcasts could begin in time for the 1996 Summer Olympics. At first, HDTV-capable sets are expected to cost $2,000 to $4,000.

KIM WILSON EVERSZ

Switches

Clap On, Rover

Those commercials that urge you to "clap on (clap, clap), clap off (clap, clap)" don't tell the whole story about the Clapper device hawked endlessly on television during holiday seasons. Just ask a Northern California woman who received one as a gift and promptly installed it on a lamp in her living room. Whenever someone knocks on the door, the woman's eight-pound Maltese dog, Daphne, barks. But now, the light switches on and off ad nauseam until the Maltese calms down.

According to manufacturer Joseph Enterprises in San Francisco, the woman is using the newest model, called the Smart Clapper, which comes with an "Away" home-security setting. Any moderately loud noise, such as a dog barking or even a table being bumped, activates the unit, which is installed between an appliance and an electrical outlet. But, says Daphne's owner, the "At-Home" setting produces the same result. The gadget simply isn't sensitive enough to differentiate between a double clap and a loud noise.—*Sandy Reed*

Home Video

Ghost Busters Are Coming

TV sets will soon be able to purge those pesky shadows that degrade picture quality. Like a visual echo, ghosts are sometimes caused by a broadcast signal bouncing off a skyscraper or by an unshielded cable acting as an antenna ["Ghost Busters," Nov. '92].

Since ghosts are most blatant—and bothersome—on large-screen TVs, the first sets to be "ghost-cancellation-ready" will be projection-type sets sold under the Philips and Magnavox names. They will have a plug on the rear jack that accepts a ghost-cancellation processing box, which is about the size of a cable box. The TVs and the processor will be introduced simultaneously in 1994. While the ghost-cancellation-ready projection TVs won't be sold at a premium, the ghost-busting box is expected to cost at least $300. Eventually, the ghost-busting circuitry will be built-in.

The processor works with the Ghost Cancellation Reference (GCR) signal developed by Philips Laboratories and is already being broadcast by about 100 stations.—*Marcelle M. Soviero* PS

Radio

Reading Your Car Stereo

Ready to scan the car radio for some rock 'n' roll? The ability to selectively scan radio stations by program type is one of the advantages of a new technology called the Radio Broadcast Data System (RBDS). The RBDS signal allows broadcasters to transmit program format information (such as rock or classical) and call letters. The RBDS signals are incorporated into the normal AM/FM signals and are currently being broadcast by more than 50 stations nationwide.

Denon America has introduced the first car audio receivers capable of digitally displaying RBDS information on an eight-character liquid-crystal display. The receivers feature a Traffic Announcement Identification mode that provides continual updates on traffic conditions. The Denon DCR-930R receiver costs about $600 and features a cassette deck, Dolby C Noise reduction, and 30 station presets. A less expensive model, the $450 DCR-730R, is also available. Blaupunkt, Onkyo, Philips, and Sony, among others, will introduce receivers for the car or home.—*M. M. S.*

Denon's DCR-930R displays radio station name and location.

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HOME TECHNOLOGY

EDITED BY SANDY FRITZ

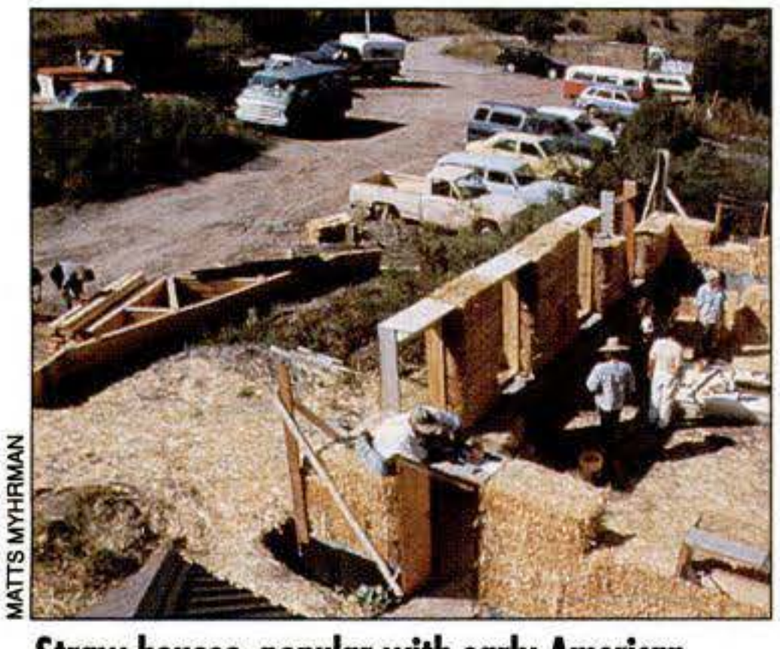
BUILDING MATERIALS

No Three Little Pigs Jokes, Please

Like to build your next home out of a material so environmentally sound that using it helps prevent air pollution? A material that insulates so well it puts conventional materials to shame? Try straw, says a tiny but growing number of American home builders.

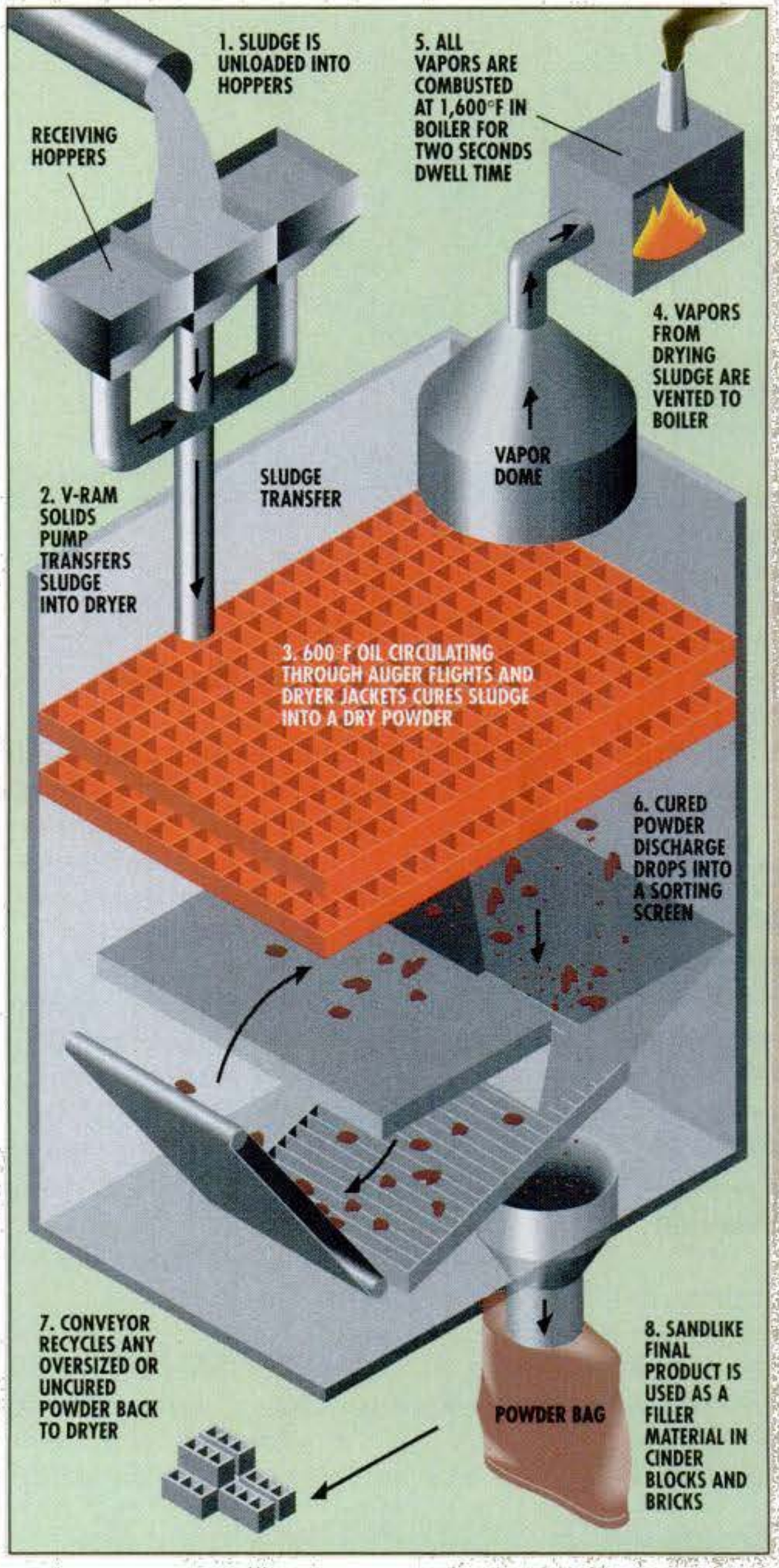
Matts Myhrman, president of Out On Bale in Tucson, Ariz., points out that the several million tons of straw burned each year could easily be turned into housing. All it takes is a concrete foundation, plus, of course, the straw. Bales of straw can be laid like bricks to form load-bearing walls or nestled into a wood frame that supports the roof. A gap can be left in the bales for windows and doors, or, if preferred, a chain saw can be used to slash through the walls to create openings. The finished product, coated with cement or stucco, is as fire-resistant and termite-proof as conventional construction.

In addition to its low cost, straw traps air, giving a standard 16- to 23-inch-thick wall an R-value of between 40 and 60, says Myhrman. The downside: Building codes don't yet recognize straw-bale construction. That may soon change, however. "We're negotiating with city and county officials in Tucson to amend their codes," he says. —*Jonathan Beard*



MATTS MYHRMAN

Straw houses, popular with early American sodbusters, are making a comeback in the Southwestern states.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SLUDGE TRANSFER
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3. 600°F OIL CIRCULATING THROUGH AUGER FLIGHTS AND DRYER JACKETS CURES SLUDGE INTO A DRY POWDER
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7. CONVEYOR RECYCLES ANY OVERSIZED OR UNCURED POWDER BACK TO DRYER
POWDER BAG
8. SANDLIKE FINAL PRODUCT IS USED AS A FILLER MATERIAL IN CINDER BLOCKS AND BRICKS

JARED SCHNEIDMAN

Driving volatile compounds from paint requires high temperatures.

RECYCLING

Into The Frying Pan

In the past, waste paint was disposed of in one of three ways: It was incinerated, blended into an alternative fuel, or dumped into a landfill. Now there's a fourth option.

Environmental Purification Industries in Toledo, Ohio, recycles paint using the Haden Dry Pure System. Paint is first blended together, then pumped into an "oven" where it is "fried" to drive volatile components and water into a gaseous state. The vapors are then collected and burned while the remaining solids—composed of pigment, filler, and resin—are reduced to granular powder. This powder is mixed with concrete or brick to give the material some degree of water resistance.

Automotive manufacturers and paint companies produce most of the waste paint that EPI recycles, but homeowners who bring their paints to household hazardous-waste programs also contribute to the nearly 2.5 million gallons of paint the plant processes each year.

HOME DESIGN

The House That's Like A Hamburger

What if designing a typical house were like ordering a hamburger? Just as you can request a Whopper with tomatoes and extra pickles (hold the mayo), you might ask for a three-bedroom ranch with energy-efficient windows and extra bathrooms—and hold the patio.

Sound appetizing? Then Roger Rasbach's new computer system is ready to take your order. Starting with any of 85 basic home layouts, the Houston architect's computer program offers a smorgasbord of 50 options, such as the type of windows, the location of fireplaces, and the slope of the roof.

Another tempting option: For those who need to start small, several "expandable" layouts can be enlarged a few years down the road with minimal trouble. The program also compares heating and air-conditioning costs for various sets of options, enabling buyers to select products that will save the most money over the long term.

Like fast-food lunches, these homes will be less expensive than other approaches. Because the structures will be built from preassembled insulated panels (layers of Styrofoam-like insulation sandwiched between boards), carpenters will have only a few dozen panels to bolt together—reducing labor expenses. In the Houston area, for example, a 2,500-square-foot layout would cost between $75,000 and $200,000, depending on options. The first prototype home is scheduled to be built near Houston this summer. —*Robert Langreth*

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VENTILATION

DON'T BE SQUARE

All things being equal, round ducts beat square ducts in creating more efficient airflow.

Now that furnace and air-conditioning technology is approaching maximum design efficiency, the ductwork that transports heated or cooled air in homes and businesses has taken on greater importance.

Officials at ASHRAE, the Association of Heating, Refrigeration and Air Conditioning Engineers, caution that ducts must have the same interior surface area for any assessment to be valid. "I can design a square duct system that's just as efficient as a round duct system," says Jim Norman, technical services representative for ASHRAE. "But if you have a round duct and a square duct with the same interior surface area, the round one will be more efficient."

Other experts counter that the real cost to consumers is inefficient heating and cooling due to the type—not the shape—of ductwork. Inefficient corrugated or flexible ducts can create air drag, and improperly sealed joints can allow conditioned air to escape into wall cavities, attics, and other unconditioned spaces.—*Michael Morris*

AIR-CONDITIONING

COOLING DRIES UP

The future of air-conditioning may be in hot wheels that drink—a lot—while they drive.

Desiccant (derived from the Latin for "to dry") wheels coated with white crystalline titanium silicate powder form the cornerstone of a new cooling system by removing up to 90 percent of the moisture from incoming air. The dried air is then chilled by adding back some moisture—much like the inexpensive "swamp" coolers long employed in arid climates.

Patented by Englehard of Iselin, N.J., the new wheel absorbs up to twice the amount of moisture as competing substances such as silica gel or lithium chloride. To dry the titanium silicate material, air heated by a gas flame is run through the other side of the wheel as it turns.

A five-refrigeration-ton version of the system, dubbed Desert Cool, will be field-tested this year by its manufacturer, ICC of Philadelphia; ICC plans a range of equipment sizes. —*Mariette DiChristina*

Mighty mouse: Mikita's cordless tile cutter is strong enough to impress the pros.

POWER TOOLS

TILE BY FIRE

To expose its strengths and weaknesses, we subjected the Mikita cordless tile cutter to the acid test by placing it in the hands of two professionals who were replacing some flawed marble tile.

The Mikita, whose blade and water bottle distinguish it from the company's cordless saw ["Home Newsfront," July], surprised both of our craftsmen. Due to its low rpm, it made clean, easy cuts through marble tile without chipping. The pros also praised the unit's water-feed system, and they quickly learned to fine-tune the valve to adjust the water flow for optimal cooling and lubrication. An extension cord can cause accidents, so the pros appreciated the absence of one.

After their initial suspicion turned to admiration, our testers were reluctant to relinquish the tool—until it ran out of battery power about 30 minutes later. Still, this did not dim their impressions of the cutter. "This is a wonderful tool," said one craftsman who has been cutting tile for 40 years. Its suggested retail price with battery and recharger is about $300.

An independent assessment of cutting rates revealed that it takes about 60 seconds to cut through a foot of hard tile, such as marble; 45 seconds for a foot of soft tile; and about two minutes for a foot of window glass.

PEST PROFILE

TERMITE TERMINATOR

For every human being on Earth there exists 1,500 *pounds* of hungry, wood-eating termites. That's a pretty big biomass in search of food. "There's an awful lot of them around," says Joe Maldon of the U.S. Department of Agriculture's Forest Service Research Lab in Gulfport, Miss., "and they forage all the time. To them, a house is just dead wood."

But termites that attempt to move into homes treated by entomologist Nan-Yao-Su from the University of Florida at Ft. Lauderdale are bound to stop dead in their tracks. Su has found that the chemical hexaflumuron—widely used in Europe as a pesticide but largely ignored in the United States because it has failed to eliminate major agricultural pests—interferes with a termite's life cycle by inhibiting its production of chitin, a hard material that makes up the insect's protective coating. As termites grow, they shed their old coat and develop a new one. But when they ingest bait laced with hexaflumuron, the chemical interferes with the coat exchange. "They become trapped between a partial new molt and the older shell—and die," says Su.

Field tests on four infested homes terminated the pests within two months and so far have kept them away for two years, especially remarkable because Su used only 100 milligrams of hexaflumuron versus the five to ten kilograms of chemicals necessary for conventional treatments. A commercial product containing hexaflumuron is being developed by DowElanco in Indianapolis and should be available within three years. —*Patricia Barnes-Svarney*

ANIMALS,ANIMALS / EARTH SCENES

SCIENTIFIC NAME: ***Reticulitermes flavipes***
COMMON NAME: Subterranean termite
NATURAL HABITAT: Dead wood, soil
ADOPTED HABITAT: Wood-frame structures
PESTY BECAUSE: Ingests wood frames and supports, weakening structural integrity.
PROFILE: The ultimate recyclers, the 40 termite species found in the United States routinely eat their own vomit, feces, and dead. They will chew through asphalt, rubber, lead, and a host of other seemingly impregnable materials in order to reach wood. Termites are experts at the art of concealing themselves; winged varieties swarming to colonize new areas are usually the only clue a homeowner has that there is a problem afoot. Detection and treatment are tricky and are best left to professional exterminators.

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TOOL SAFETY

No More Dust In The Wind

The federal government has strong-armed makers of small power tools into taking a hard look at their dust. The Occupational Safety and Health Administration (OSHA) wants to reduce maximum workplace dust concentrations from 15 to 5 milligrams per cubic meter of air. And though OSHA usually targets industries, power-tool manufacturers say the agency is now quietly telling them to make all their products much less dusty.

The result has been a growing trend toward vacuum-assisted exhaust points on everything from drills to routers. For instance, when Bosch introduced its Air Sweep dust-collection system back in the 1970s, it fit only a few of the company's tools. Now virtually all products in the company's woodworking line have been redesigned to accommodate the system. Other companies are following suit. Rotary hammer drills by Hilti and Hitachi now place suction rings for vacuum attachments near the end of the bit, while AEG has rolled out a compound miter saw with exhaust points to accommodate vacuums.

The most aggressive systems are appearing on random-orbit sanders, some of which now include built-in exhaust fans. Fein, Makita, Milwaukee, and Porter-Cable use preformed holes in the sandpaper to pull dust from the work surface before it becomes airborne. Fein's random-orbit sander goes a step further, pulling dust through slits in the edge of the backing pad. According to Fein, these systems catch up to 98 percent of all sanding dust.—*Charles Wardell*

The next generation: They could be nearly dust-free.

APPLIANCES

Dueling Refrigerators: The Final Battle

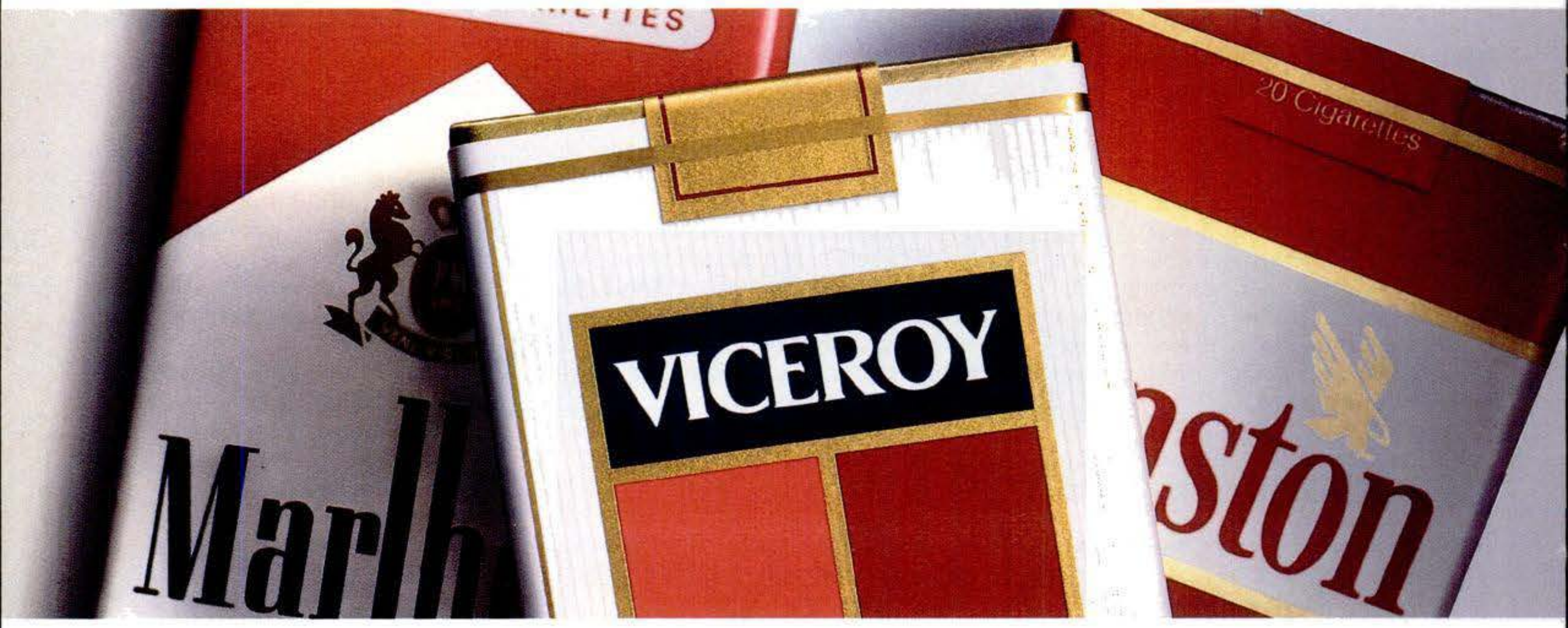
The battle of the energy-efficient refrigerators has entered its final round.

It began with 14 high-tech, energy-saving, ozone-friendly prototypes vying to win the first-ever "Super-Efficient Refrigerator" competition. Last December, the 24 utilities that dreamed up the contest whittled down the field to two finalists, one from Frigidaire and one from Whirlpool; this month they crown a victor.

The champion company gets more than bragging rights—it also snags a $30 million bounty offered by the utilities. The rules are simple: Each new refrigerator must work twice as efficiently as the average U.S. model without using ozone-destroying chlorofluorocarbons (CFCs); the manufacturer must also detail its plan for marketing the unit nationwide.

The triumphant super-fridge, which looks like a conventional refrigerator on the outside, could reach stores by 1994.—*R. L.*

The right taste.



SURGEON GENERAL'S WARNING: Quitting Smoking Now Greatly Reduces Serious Risks to Your Health.

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RESEARCH

QUANTIFYING EMFs

It's early morning, and you're sitting in the kitchen eating cold cereal. At the same time, the refrigerator, clock, and electric stove are generating invisible electromagnetic fields, or EMFs. What EMF levels are reaching you? Scientists from the Electric Power Research Institute (EPRI) in Palo Alto, Calif., are seeking the answer in a survey of 1,000 randomly selected homes.

Electric and magnetic fields occur together in low-frequency alternating-current power. The combination can create temporary electrical currents in living tissue, a situation some researchers contend may promote cancer. In addition to appliances, EMF sources include a house's grounding system, overhead power lines, and some older types of electrical wiring.

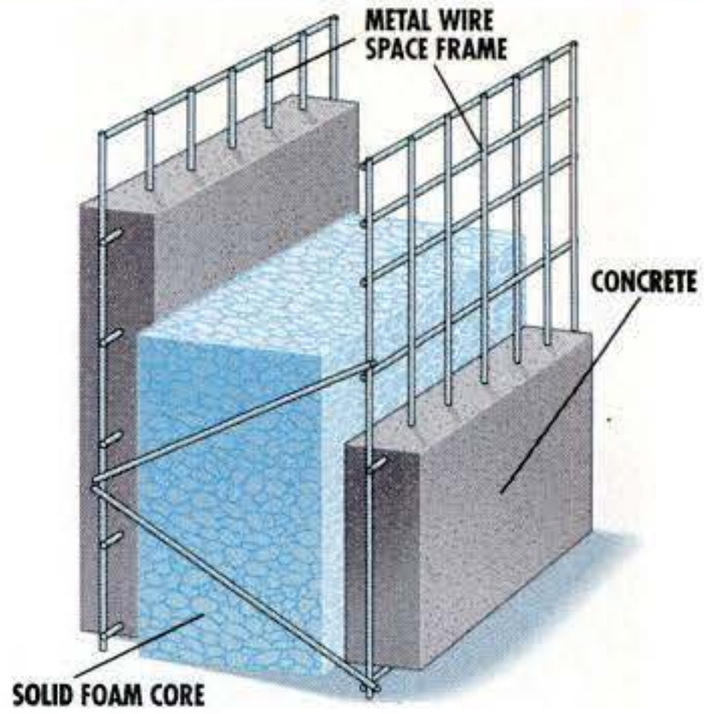
So far, EPRI surveyors have measured EMF levels in the center of rooms, around the house periphery, and at various distances from appliances and nearby overhead electric lines in 701 of the 1,000 homes. EMFs measured a benign one milligauss (a measure of electromagnetic radiation) or less in areas free from appliances. Near appliances, however, the surveyors found that EMFs can be significantly higher. —*M. D.*

BUILDING PANELS

HURRICANE ANDREW A YEAR LATER

A year ago this month, Hurricane Andrew rolled over southern Florida, leveling nearly 80,000 homes and ripping up much of southern Florida's infrastructure. Structures that survived the disaster included all of the 15 houses built in Dade County by Habitat for Humanity, an Atlanta-based organization that uses volunteer labor to construct low-cost homes. As 160-mph winds walloped an Air Force base and uprooted neighboring homes, the Habitat houses—including one in the devastated Homestead area—remained firmly planted in the ground.

The Habitat houses were constructed with a new system of panels designed by Brunswick, Ga.-based Insteel Construction. The panels consist of welded wire space frames with foam insulation cores. Once in place, the panels are then sprayed on both sides with concrete. Besides costing 10 to 40 percent less than conventional wood-frame construction, the system can be assembled by unskilled workers.

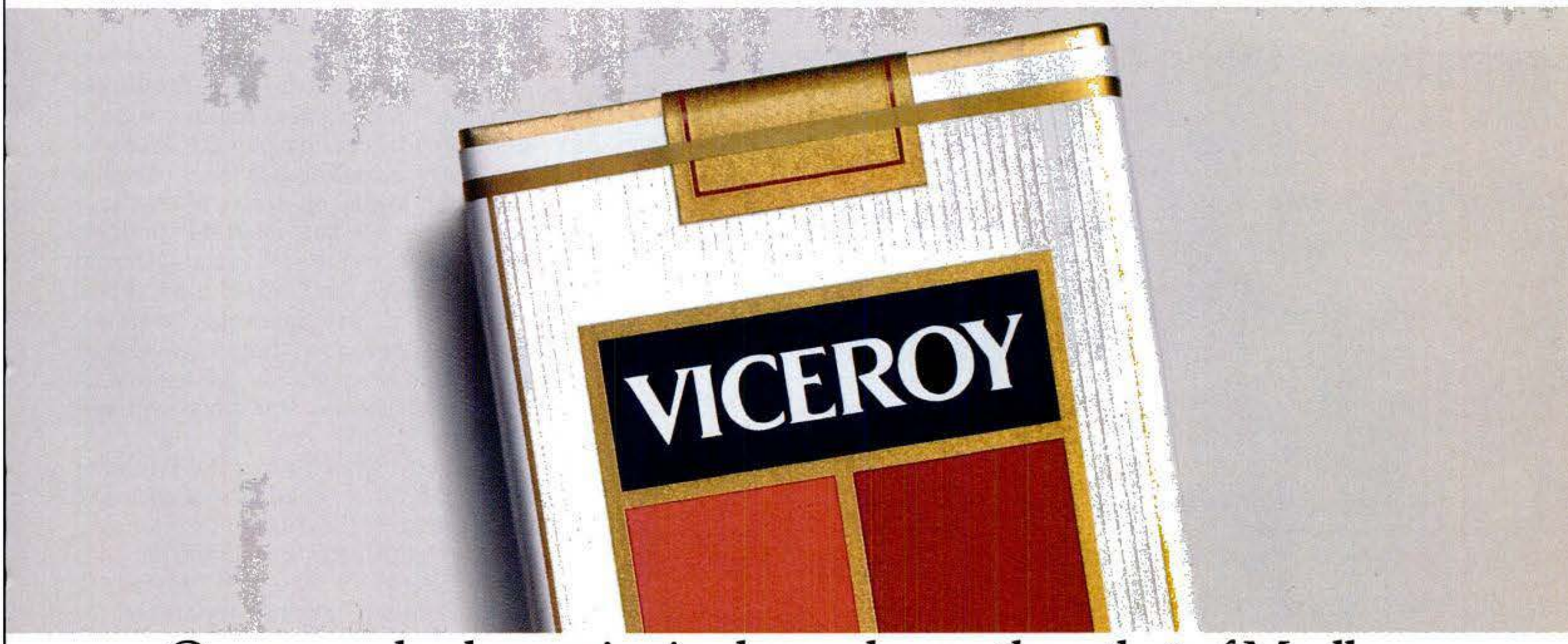


A sturdy sandwich of materials kept Habitat for Humanity homes grounded when Hurricane Andrew blew through southern Florida last year.

STEVE STANKIEWICZ

Investigation of the damage in Florida revealed that many conventionally built homes lost their roofs and consequently their walls. The combination of sturdy walls and hurricane clips, plates that secure each individual roof truss to the walls, helped the Habitat structures escape this fate. Hurricane clips, which are attached to the top of the wall panels, are the only way to fasten the roof to the walls.—*C. W.* PS

The right taste at the right price.



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COMPUTERS & SOFTWARE

EDITED BY CHRIS O'MALLEY

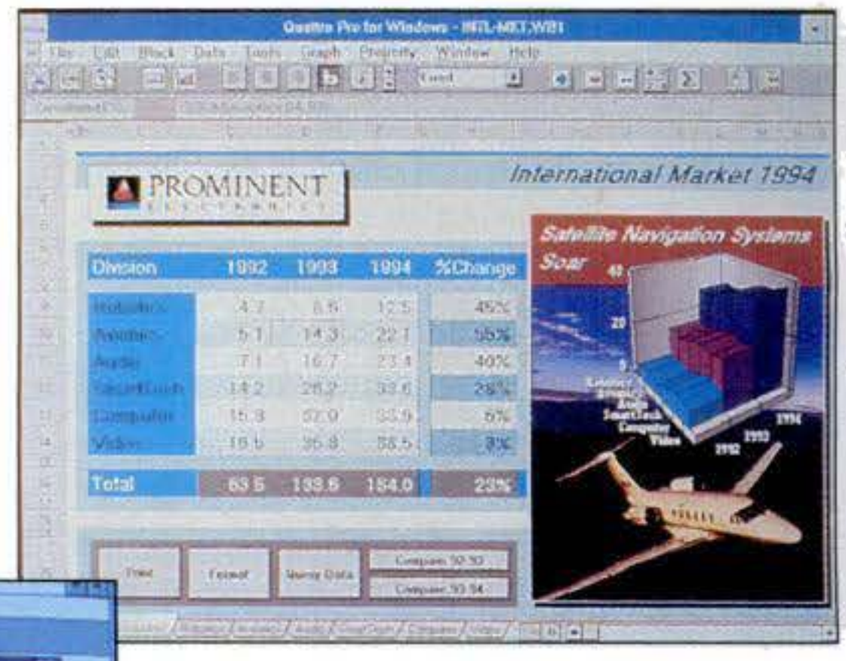
FUTURE WATCH

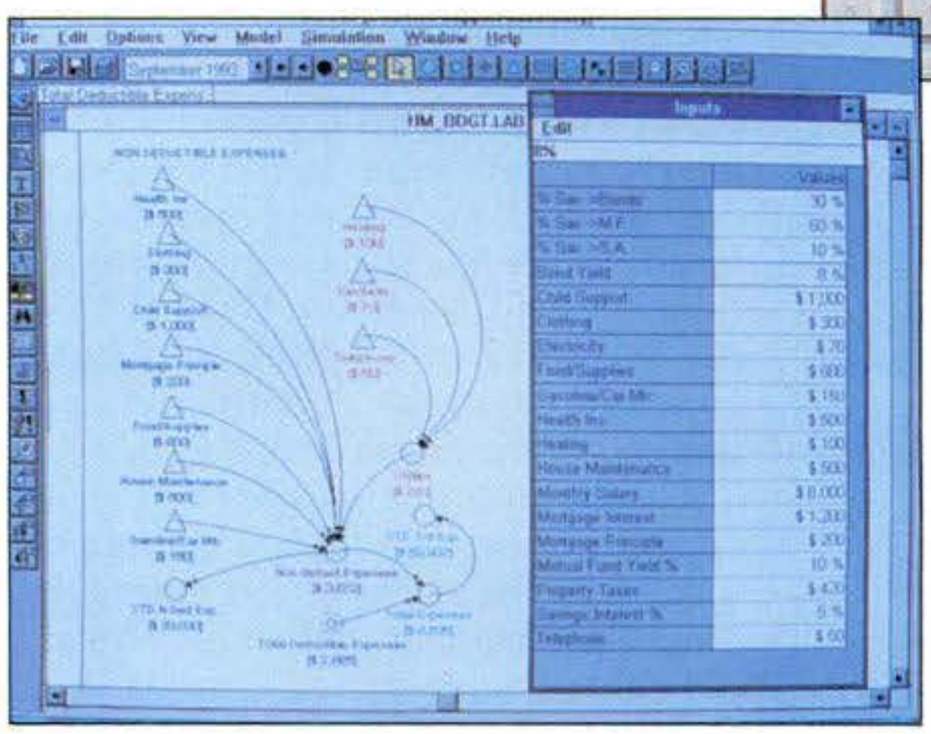
THE WALLET PC, ACCORDING TO GATES

Someday, reaching for your wallet and booting up your PC may be the same thing—at least if Microsoft Corp. chairman Bill Gates has anything to do with it. In a speech earlier this year at the University of Washington, Gates outlined his vision of bringing personal computing beyond the desktop and into your pocket.

The Wallet PC, according to Gates, might replace credit and identification cards and cash with electronic cards that continually update balances and personal information. Small color displays could even show family snapshots, in addition to providing handy date-book and calculator-type functions. But your Wallet PC could play other roles too, such as acting as an integrated global positioning device with on-screen maps to help you find your way around an unfamiliar place, for example. A wireless communications system might enable you to send and receive messages or check the latest news or weather.

In case you still wanted to use a desktop PC, you would be able to pass information back and forth by simply waving your wallet (or a removable card) in front of the desktop system. While many of the components of Gates's vision are already here, Gates concedes it may be years before the Wallet PC becomes a reality.





Eschewing the dusty ledger format, new spreadsheets such as DS Lab (left) and Quattro Pro for Windows (top) are adopting simpler, more visual approaches to dealing with numbers. DS Lab uses flowcharts to show relationships, while Quattro Pro uses tabbed sections in a notebook format.

SOFTWARE

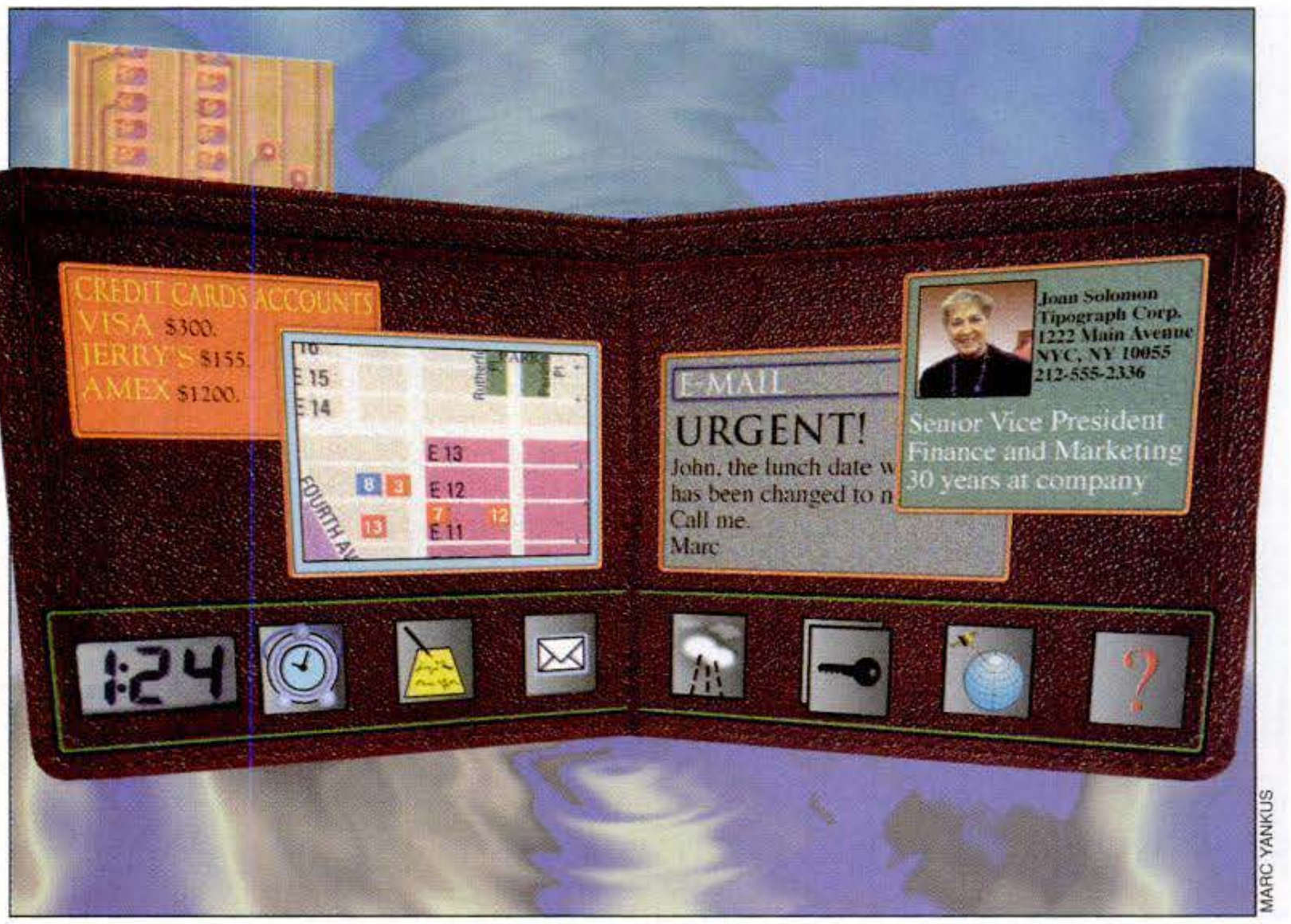
NEW DIMENSIONS IN NUMBER CRUNCHING

Since its debut in the late 1970s, spreadsheet software has adhered closely to the row-and-column format of the paper ledgers it was designed to replace. Several new spreadsheet programs are now tinkering with that rigid paradigm, enabling anyone to create more informational work sheets.

Lotus's Improv, recently released for the Windows environment, was among the first programs to tinker with spreadsheet customs by replacing normally cryptic formulas and cell identifiers with plain English—a practice that has since been adopted by other programs. Instead of using a formula such as "E6=B3*D5" to determine the cost of goods, for example, a plain-English approach could be written "cost of goods = revenue * 55%." That not only makes formulas easier to write, it makes them easy to reuse and easy for others to understand.

A new Windows spreadsheet called DS Lab, from start-up DS Labs Group of Greenwich, Conn., further simplifies spreadsheets by using flowcharts to illustrate the relationships between different kinds of data. With these flowcharts, symbols such as triangles and circles represent variables, constants, tables, and other data types. The symbols are connected with arrows to show how they impact each other. The program can be used with data taken from a traditional spreadsheet too.

Borland's Quattro Pro for Windows also employs a visual device to make its number crunching more understandable. Quattro Pro organizes each spreadsheet as a "notebook," or a stack of worksheet "pages" separated by tabs similar to those in an address book. Touching one of the tabs, which can be labeled to suit your purpose, brings you to that page. Lotus's new 1-2-3 for Windows 4.0 uses a similar technique to arrange its work sheets.—*Suzanne Kantra*



MARC YANKUS

Tomorrow's Wallet PC might be a billfold-size combination of today's pocket organizers and personal communicators, with cash, credit cards, and paper identification replaced by electronic "smart cards."

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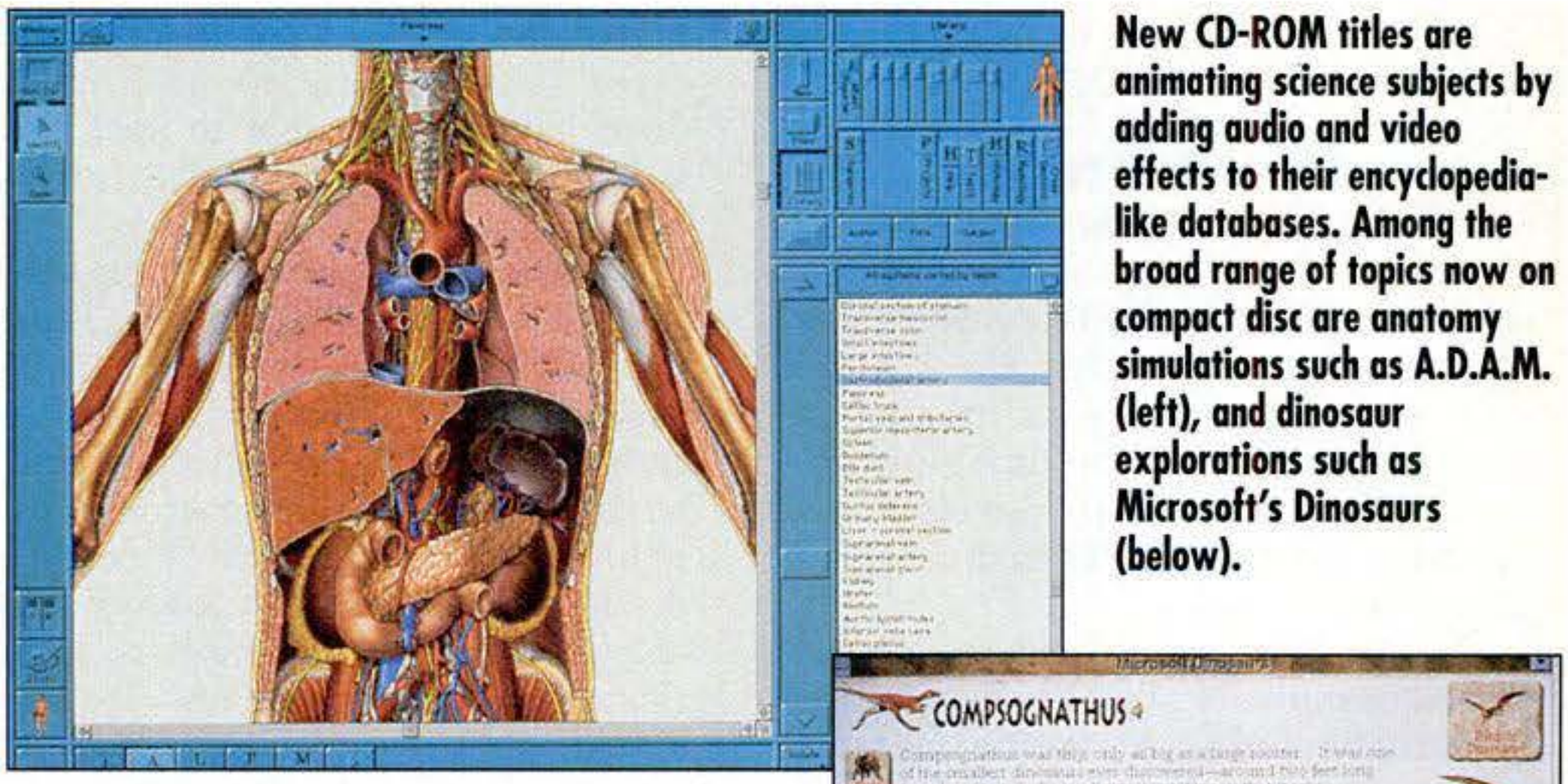
UPGRADES

RELIEF FOR EXPANSION FRUSTRATION

Adding a video adapter, CD-ROM interface, or any other type of internal circuit board to your IBM-compatible PC can be a hassle because of an arcane maze of tiny switches, interrupt settings, and memory conflicts. But a new standard proposed by Microsoft, Intel, and Compaq could make upgrading easy.

The so-called Plug and Play Specification requires board makers to assign specific identifications to their products that would enable a PC to "see" what's in each of its expansion slots, allocate the proper memory, and retain the needed configuration information in a special database. (Macintosh users already enjoy the simplicity of adding boards without configuration problems.) Boards compatible with the new specification could begin appearing later this year. Initially, the Plug and Play standard applies only to the Windows operating system and 16-bit or ISA (Industry Standards Architecture) systems using Intel microprocessors. In the future, it's expected to apply to all types of PCs. The new standard also covers the credit-card-size add-ons known as PCMCIA cards.



New CD-ROM titles are animating science subjects by adding audio and video effects to their encyclopedia-like databases. Among the broad range of topics now on compact disc are anatomy simulations such as A.D.A.M. (left), and dinosaur explorations such as Microsoft's Dinosaurs (below).

CD-ROMs

BRINGING SCIENCE TO THE SHINY DISC

Complex subjects such as space, ecology, and evolution don't easily translate into short descriptions or static images. But CD-ROM discs have both the room and high-quality audio and video to make science come alive—and there's been an explosion of new CDs that do just that.

Some of the best new science titles are published by Warner New Media. Murmurs of Earth ($60) is a copy of the record that went into space in 1977 with the Voyager spacecraft on its search for extraterrestrial life. Like the original, this CD-ROM includes music, greetings in 55 languages, messages from world leaders, and color photos of Earth. Warner's The View from Earth ($80) focuses on eclipses and includes an animated slide show of the July 1991 total solar eclipse as filmed from Hawaii's Mauna Kea volcano. Both are available for IBM-compatible or Macintosh systems.

Not all of the best titles are adaptations. Fractal Ecstasy ($80) from Deep River Publishing uses Video for Windows, which requires Microsoft Windows 3.1, for viewing and creating fractal "fly-throughs," images that you can "walk" through. New CDs from Knowledge Adventure include Science, Dinosaur, Space, and Animal Adventure titles ($70 to $80). Animal Adventure and Version 2.0 of Isaac Asimov's Science Adventure, both for IBM-compatible PCs, use compressed full-motion video to create a three-dimensional effect to "walk" you through the program using a mouse. Microsoft recently released a CD-ROM called Dinosaurs ($80) for Windows as well.

Science CDs for professionals are becoming more sophisticated too. One example is the newly completed A.D.A.M. (Animated Dissection of Anatomy for Medicine) series from the company of the same name. It provides an accurate simulation of the human anatomy for health-care workers, educators, and others. The entire program costs $2,795 and runs within Windows or on a Mac. Modules covering specific anatomy areas are also available.—*Sandy Reed*

USED PCs

NEW LIFE FOR OLD COMPUTERS

Personal computers can go from pioneering to passé in a matter of months, so it's no surprise that Americans discard more than ten million PCs and peripherals every year. There are alternatives to throwing away computer equipment or letting it gather dust in the closet, however. Below are a few suggestions.—*Mariette DiChristina*

DONATE:

- Local school boards and nonprofit organizations often accept used computers and printers.
- The National Cristina Foundation (800-274-7486) matches used PCs with people who are disabled or disadvantaged.
- The East-West Education Development Foundation in Boston (617-542-1234) refurbishes old computers and gives them to groups in 130 countries.

BUY & SELL:

- Local PC users groups and newspapers often have special advertising forums for used computers.
- The American Computer Exchange in Atlanta (800-786-0717) matches buyers and sellers.
- Boston Computer Exchange operates a telephone hot-line (800-262-6399) for buyers and refers out-of-town callers to buyers and sellers in their area.
- The $99 Orion Computer Blue Book (602-951-1114), also available on disk, estimates the value of used PCs among its 28,800 listings.

RECYCLE:

- Some local metal recyclers may accept old PCs.
- A few companies, such as Advanced Recovery in Belleville, N.J. (201-450-9797), and Ecology Plus in San Jose, Calif. (408-452-7717), specialize in computer recycling.
- Several printer manufacturers, including Hewlett-Packard (800-752-0900), Lexmark (800-848-9894), Canon U.S.A.(800-962-2708), and Apple (800-795-1000) accept old toner cartridges for recycling.

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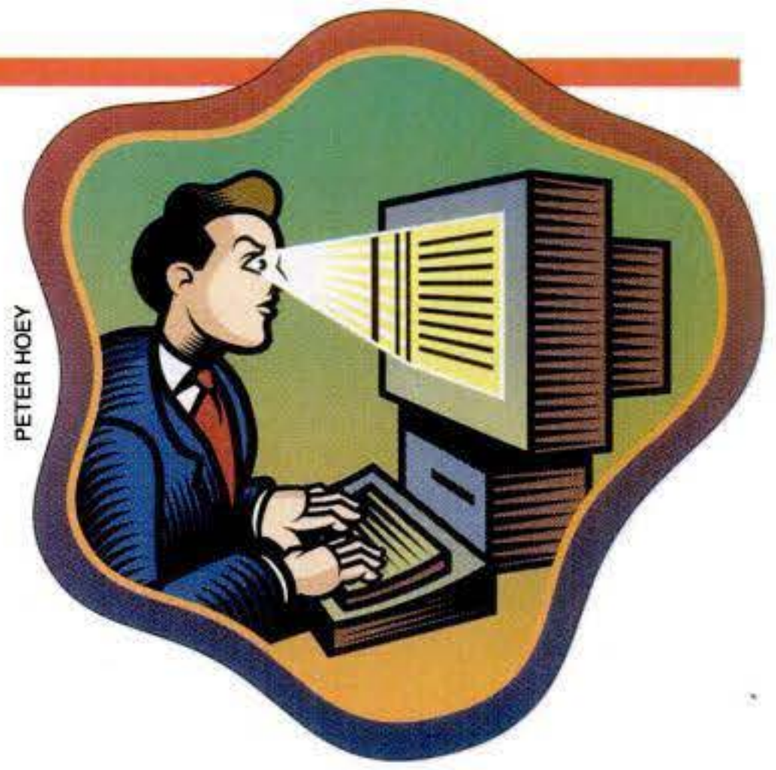
DIGITAL IMAGING

NEW METHODS FOR SPOTTING CANCER

In the battle against breast cancer, early detection is often the key to a positive prognosis. And researchers are turning to digital imaging and computer analysis to develop new systems for detecting breast cancer in its earliest stages.

At Sandia National Laboratories in Albuquerque, N.M., the X-ray films generated during a routine mammogram are being digitized and then analyzed by a software program developed to search for visual features common to cancerous lesions. Star-shaped distortions in the breast tissue called stellate lesions, which are not only indicators of tumors but are also frequently cancerous themselves, are one of the primary visual signs of breast cancer. But they are difficult to detect because of their varied appearance. Software is able to spot these subtle changes with powerful new algorithms.

Similar hopes are being raised at the University of Toronto's Sunnybrook Health Science Center. A new process dubbed digital radiography couples standard X-ray techniques with a solid-state detector, which replaces photographic film. The detector absorbs the X-rays after they have traveled through the breast tissue and generates an electronic signal to form an electronic image. The results are much more detailed than photographic film, and they can be manipulated and enhanced easily on a computer. The new process is also able to create a 3-D topographic map of the breast that helps in identifying regions that may be at higher risk for future cancer development. —*S. K.*


PETER HOEY

HEALTH

TOO MANY DRY EYES IN THE OFFICE

Does gazing at your computer screen make your eyes weary? It's a common complaint, and one that's blamed on everything from improper screen height to electromagnetic radiation. But a recent study suggests it's your eyes that may be on the blink—by not blinking enough.

Blinking keeps your eyes moist, which helps avoid discomfort. However, people who use computers tend to stare more steadfastly at their monitors and blink less often than they normally would, according to the Japanese study. That combination leads to dry, irritated eyes. Eye drops can help, but the best prescription may be to take a break and bat your baby blues.

COMPUTERS

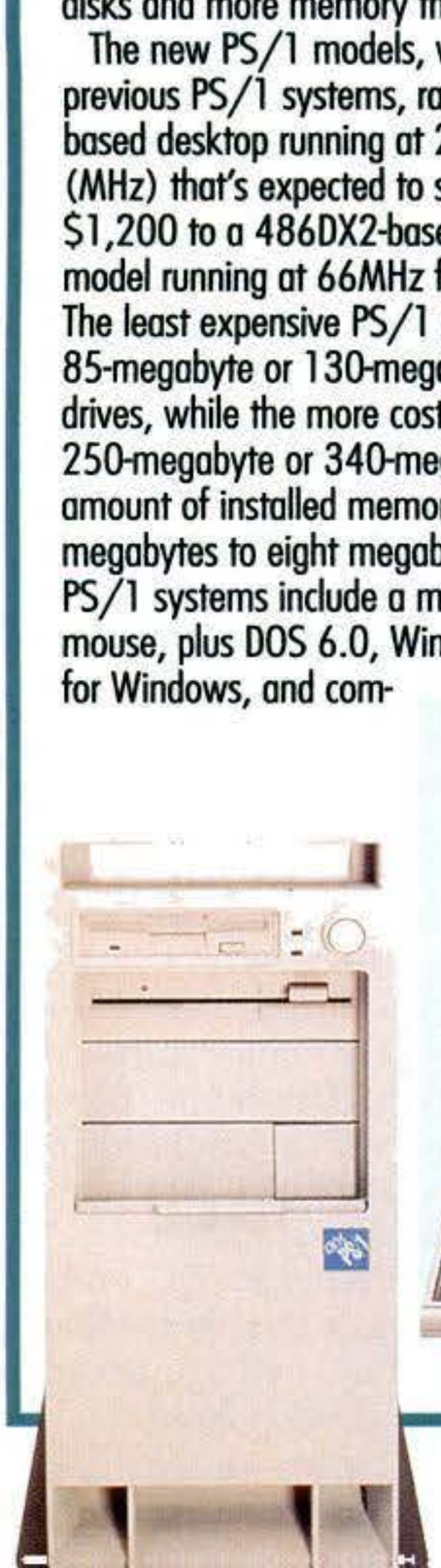
THE PS/1 GETS A POWER LIFT

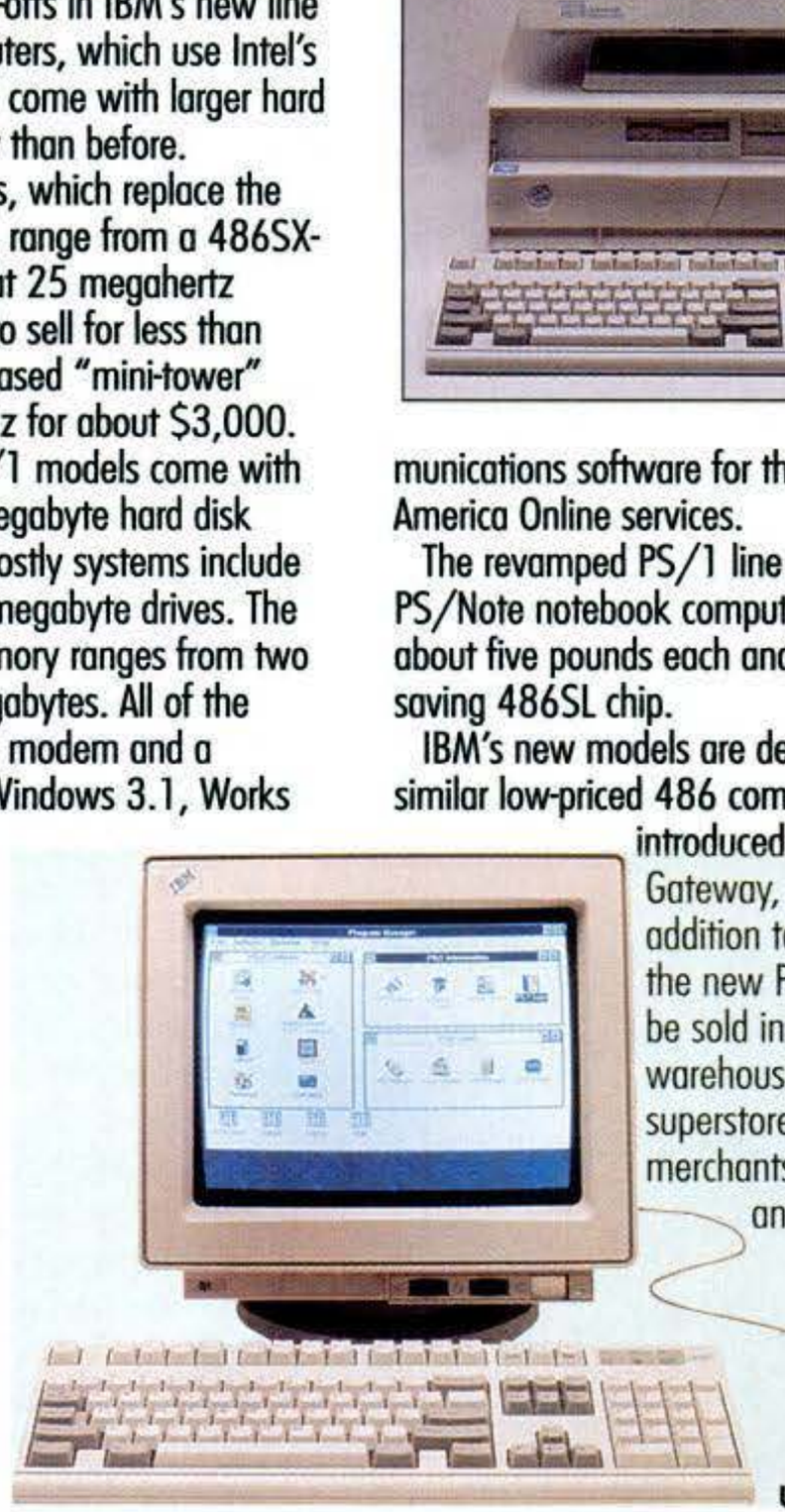
Buying a PC on a tight budget often means trading higher speeds for lower prices. But there are few trade-offs in IBM's new line of low-cost PS/1 computers, which use Intel's fast 486 processors and come with larger hard disks and more memory than before.

The new PS/1 models, which replace the previous PS/1 systems, range from a 486SX-based desktop running at 25 megahertz (MHz) that's expected to sell for less than $1,200 to a 486DX2-based "mini-tower" model running at 66MHz for about $3,000. The least expensive PS/1 models come with 85-megabyte or 130-megabyte hard disk drives, while the more costly systems include 250-megabyte or 340-megabyte drives. The amount of installed memory ranges from two megabytes to eight megabytes. All of the PS/1 systems include a modem and a mouse, plus DOS 6.0, Windows 3.1, Works for Windows, and communications software for the Prodigy and America Online services.

The revamped PS/1 line also includes three PS/Note notebook computers, which weigh about five pounds each and use Intel's power-saving 486SL chip.

IBM's new models are designed to counter similar low-priced 486 computers recently introduced by Compaq, Dell, Gateway, and others. In addition to computer stores, the new PS/1 systems will be sold in department stores, warehouse clubs, office superstores, and even mass merchants such as Wal-Mart and K Mart.





IBM's new PS/1 computers all use 486 chips, a step up from earlier PS/1 models.

ON-LINE SERVICES

COMPUTER CLASSIFIEDS GET THE JOB DONE

With the number of on-line services and the number of people looking for work both on the rise, it was only a matter of time before employment advertising leapt from the classified pages to the computer screen. A new on-line job-recruiting system from Drei Tauben Ltd. in Jersey City, N.J., focuses on job opportunities in the computer field.

The service, called Allée (French for "pathway"), leads you through general questions regarding your experience and the type of job you're seeking. The system then searches its database to find possible matches.

The nationwide service is sponsored by a group of about 130 colleges and universities known as the University Employment Consortium and can be accessed 24 hours a day with a modem for the cost of the call (908-613-0500). —*Marcelle M. Soviero* PS

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Have you driven a Ford...lately?

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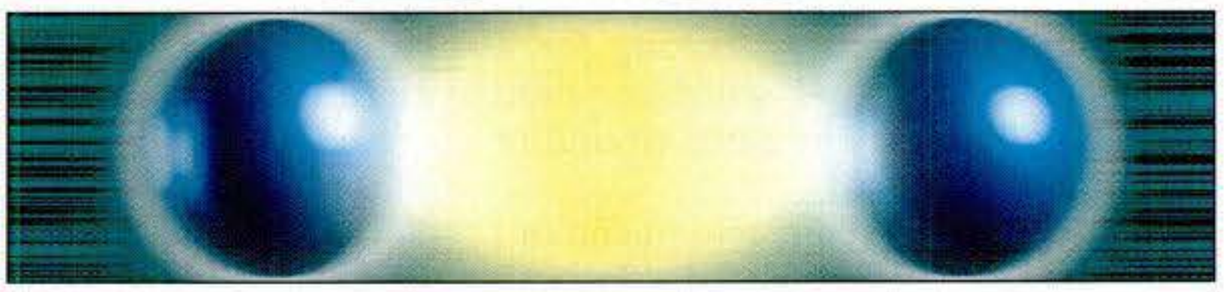
Popular Science
AUGUST 1993

It ain't over till it's over...

COLD FUSION



The controversial dream of cheap, abundant energy from room-temperature fusion refuses to die.

BY JERRY E. BISHOP

Four years ago, two electrochemists electrified the world—and infuriated the physics community—by claiming they had generated fusion energy in a simple tabletop apparatus using a few dollars worth of materials. This, despite the long, costly, and frustrating worldwide quest to harness the superhot fusion process that powers the stars.

In a statement released by the University of Utah, the two chemists, B. Stanley Pons and his one-time mentor Martin Fleischmann, said "our indications are that the discovery will be relatively easy to make into a usable technology for generating heat and power."

These audacious claims were met by scientific skepticism. The known laws of physics forbid hydrogen fusion except at temperatures rivaling those at star cores—10 million degrees Fahrenheit or more. The skepticism eventually turned to ridicule when hundreds of researchers, frantically trying to board the cold fusion bandwagon, could not replicate the experiment, and Pons and Fleischmann could not substantiate their claims with conclusive evidence.

Today, the majority of the world's physicists and chemists say cold fusion is impossible. They have dismissed cold fusion as a grand illusion, a case of "pathological science" in which scientists' hopes of a breakthrough cause them to see experimental results that don't exist. But a small cadre of hopeful scientists is doggedly pursuing the grail that the two chemists believed they glimpsed briefly in 1989. And in recent months these researchers have begun to report results that, they insist, not only add up to proof that a new source of energy has been discovered, but hint strongly that one or more previously unsuspected nuclear reactions have been uncovered. Among the assertions of these scientists:

- The secrets of how to reproduce the original cold fusion experiments have been ferreted out, overcoming the objections that the original experiments must have been mistakes because they couldn't be duplicated at will.
- The radiation and nuclear byproducts that are produced in nuclear reac-

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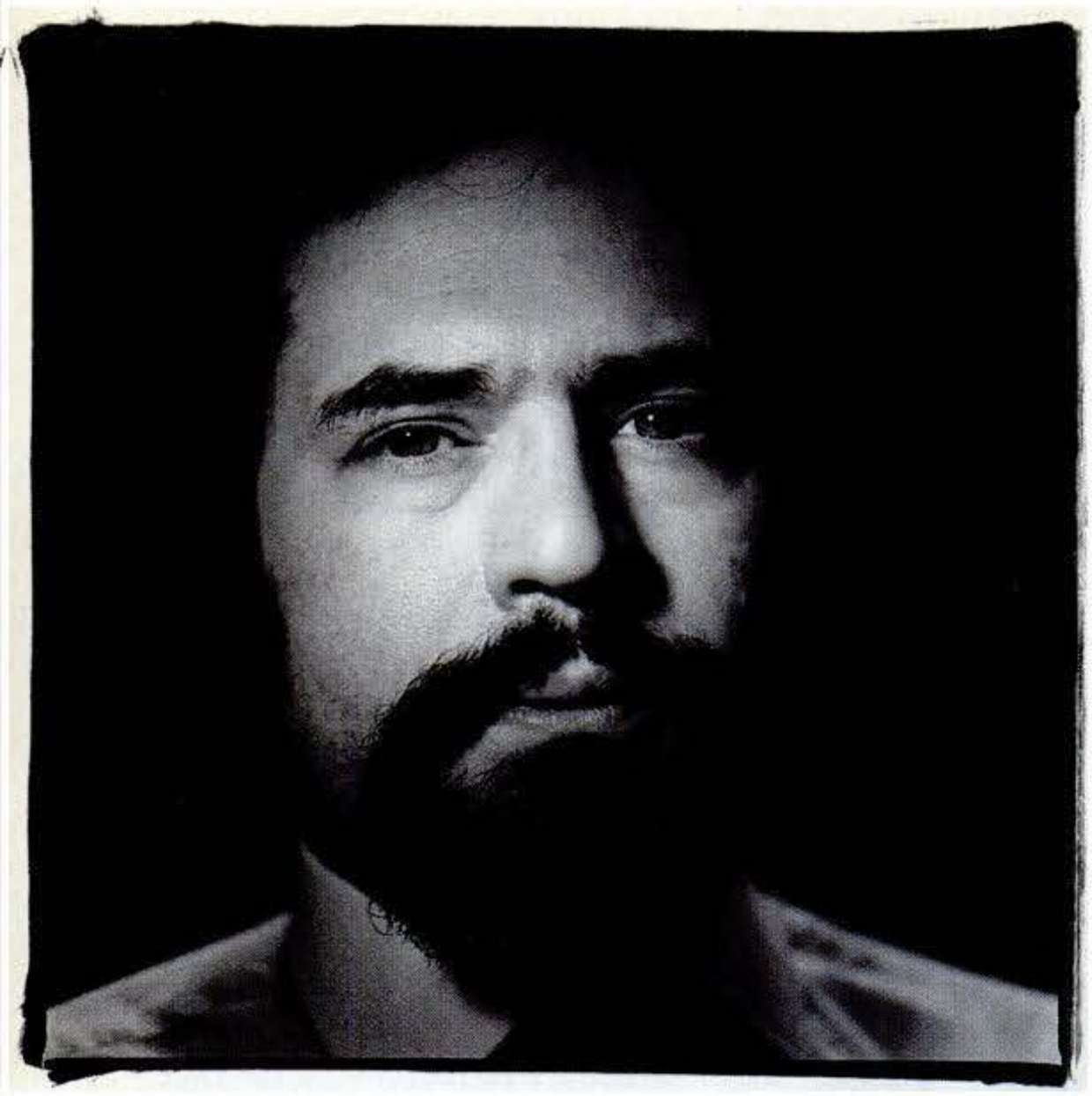

Cold fusion will end the Oil Age, beginning now. The so-called scientists who slandered cold fusion will eat mountains of crow. The party's over for the science bigots; they are the walking dead.

EUGENE F. MALLOVE,

VICE PRESIDENT FOR RESEARCH,

CLUSTRON SCIENCES CORP.

tions have been unequivocally detected in cold fusion experiments, albeit in quantities that are inexplicably low.

•And, in perhaps the most dramatic of all their claims, the researchers say that excess energy is being generated during the electrolysis of "light," or ordinary, water. "Heavy" water has deuterium, a heavy isotope of hydrogen, in place of the normal hydrogen in light water.

This last claim —the liberation of excess energy from ordinary water—is of such moment that even dedicated cold fusion scientists are approaching it gingerly. Until this claim was made, all cold fusion experiments involved the electrolysis of heavy water. Experimenters assumed that the excess energy was generated by the fusion of deuterium nuclei. But the production of excess energy during the electrolysis of light water would presume that there are nuclear reactions occurring that no one had even thought of before—and which cannot be described, much less explained.

"They called the original cold fusion announcement the discovery of the century," says one cold fusion researcher who requests anonymity to protect his funding. "If these light water experiments are true, it would be the discovery of the millennium," he says. "It would be incredibly ironic if after all these years of looking for a cheap, abundant fuel we discovered that we had been swimming around in oceans of it."

The new claims about cold fusion fail to impress orthodox scientists. John R. Huizenga, professor of chemistry and physics at the University of Rochester in New York, was in the audience at an October 1992 conference in Nagoya, Japan, where many of the new experiments, including those using light water, were described. He later told reporters he heard nothing that would induce him to retract negative conclusions in his 1992 book *Cold Fusion, The Scientific Fiasco of the Century*. In it he declares: "Marvels or surprises do occur in science, and one should be on the lookout for them. When too many miracles are required, however, as was the case for explaining room-temperature fusion in solids, strong evidence exists for pathology at work."

PHOTOGRAPHS BY JOHN B. CARNETT

This charge of pathological science leads Edmund Storms, a materials scientist at the Los Alamos National Laboratory in New Mexico, who is pursuing cold fusion, to retort: "There's such a thing as pathological skepticism, and it's just as bad and damaging as so-called pathological science."

The issue surrounding cold fusion is whether nuclei of hydrogen atoms can be forced to fuse at ordinary room temperatures, rather than in the infernos within stars (see A Fusion Primer).

During the early months of the atomic bomb project in 1942, physicist Edward Teller realized that if deuterium nuclei were plunged into the fiery furnace of the then-unbuilt atomic bomb, the nuclei would be heated to such tremendous energies —the equivalent of 400 million degrees—they would fuse when they collided, liberating energy. If enough fusions took place fast enough, an incredible amount of energy would be unleashed. That theory became reality in the hydrogen bomb.

Since then, billions of dollars have been spent trying to devise gigantic devices—including tokamaks, mirror machines, and supergiant lasers—that would force hydrogen nuclei to fuse under controlled conditions and to release more energy than it took to heat and confine them. The mordant quip favored by observers of this struggle is that controlled thermonuclear fusion is just 25 years away—and has been for the past 40 years.

Thus, it's not hard to imagine the astonishment—and consternation—that swept through the world of physics in the wake of the now-famous March 1989 press conference in Salt Lake City at which Pons told reporters that he and Fleischmann were measuring inordinate amounts of heat being generated during the electrolysis of heavy water.

Their bench-top apparatus, Pons said, consisted of a thin rod of palladium, acting as the cathode, encircled by a platinum wire that served as the anode. The two electrodes were immersed in a bath of heavy water that was salted with lithium so it would conduct an electric current.

When a voltage was applied to the electrodes, the deuterium oxide molecules would begin to break up into deuterium and oxygen, just as the electrolysis of normal water generated hydrogen and oxygen. But often and at unpredictable moments, Pons said, an extraordinary phenomenon would occur: The heavy water bath would begin to heat up.

The chemists said their calculations showed that the rate of heat energy

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coming out of the experiment was far in excess of the electrical power that went into it; for every watt of electrical power input, three to four watts of "excess" heat were being released. The intervals when the experiment produced excess heat lasted for hours or even days.

This excess heat was beyond any that could possibly be generated by chemical reactions, Pons said. Therefore, the heat must have been generated by nuclear reactions. Presumably, the palladium rod selectively sponged up the deuterium atoms liberated by the electrolysis of heavy water. Pressure inside the palladium was powerful enough to force the deuterium nuclei to fuse, releasing heat energy in the process.

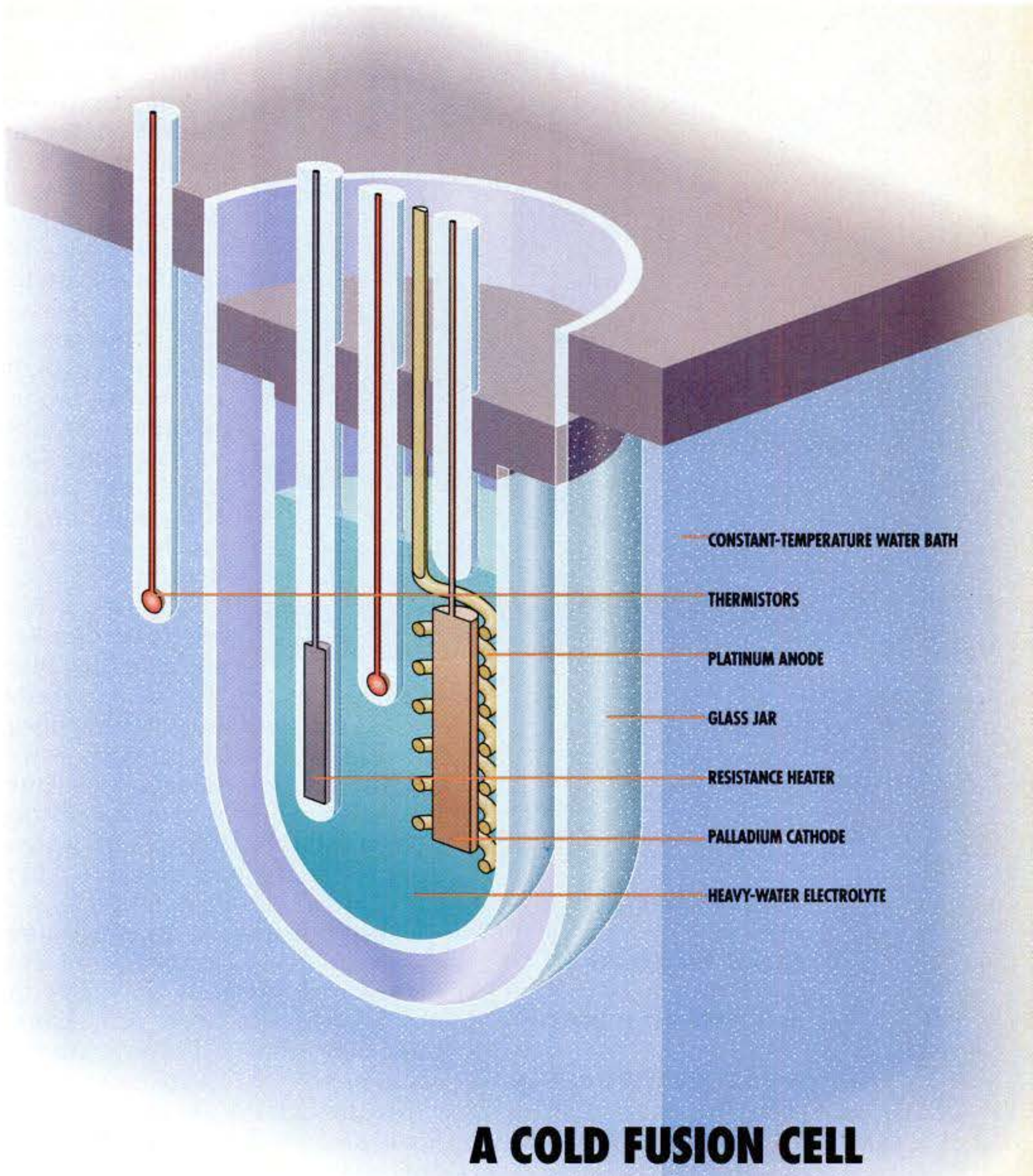
In succeeding weeks, as one laboratory after another failed to duplicate the Utah experiments, the idea of cold fusion began to seem like a mistake. Many physicists calculated that if nuclear fusions inside the palladium were generating as much heat as Pons and Fleischmann claimed, hundreds of billions of fusions would have had to occur per second, and the two chemists never would have survived the resulting radiation. Since they were alive and there was no evidence of such intense radiation, the heat measurements must be wrong, the physicists argued.

The prestigious British scientific journal *Nature*, soon declared cold fusion a mistake and said it no longer would accept articles on the subject. In November 1989, eight months after the Pons-Fleischmann Utah news conference, a U.S. Department of Energy (DOE) ad hoc panel of scientists, cochaired by the University of Rochester's Huizenga and Harvard University physicist Norman Ramsey, concluded that the evidence for a new kind of nuclear fusion "was not persuasive." The DOE immediately ended all funding of cold fusion experiments.

The National Cold Fusion Institute at the University of Utah, which had been set up by the state in the enthusiasm that swept Utah after the 1989 press conference, closed in July 1991. Its scientists, having exhausted an initial $25 million appropriation, were unable to convince the Utah legislature that the state had anything to gain from further research.

The federal government's dismissal of "cold fusion" extended even to the U.S. Patent Office. In early 1991, at least one researcher who applied for a patent on a variation of the Pons-Fleischmann experiment had it rejected on grounds that cold fusion claims by the applicant or anyone else "are not reproducible or even obtainable." The evidence cited by the examiner consisted largely of articles appearing not in scientific journals but in *The Washington Post, The New York Times, The Wall Street Journal*, and *Newsday*, all of which quoted various physicists to the effect that experiments demonstrating cold fusion were mistakes.

Not all attempts at replication were negative, however. By mid-1991, there had been at least 40 different experiments—mostly in the United States, Italy, and India—in which researchers claimed to have measured excess heat, according to a count by Edmund Storms at Los Alamos. In another dozen experiments, scientists, including Storms himself, claimed to have detected tritium, a byproduct of fusion, and three dozen others reported they had detected some kind of nuclear particle being emitted by their cold fusion experiments. None of these "positive" experiments was conclusive, but they were enough to keep the quest alive despite the dismissal by the scientific establishment.



JARED SCHNEIDMAN

A COLD FUSION CELL

The original cold fusion apparatus used by Pons and Fleischmann at the University of Utah was an electrolytic cell held in a water bath—a small glass jar immersed in a Rubbermaid dish basin. The electrodes consisted of a platinum wire—the anode—looped around a palladium rod—the cathode—immersed in an electrolyte of heavy water—99.5 percent deuterium oxide, with a salting of lithium deuteroxide to make it conductive. A low-voltage battery was connected to the electrodes, resulting in a current that electrolyzed the heavy water, dissociating oxygen from deuterium atoms, which impregnated the palladium. Thermistors monitored the temperature inside the cell and in the water bath, and an electrical resistance heater calibrated the experiment. Pons and Fleischmann claimed that the instruments measured excess heat amounting to as much as four times the power input.

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The claim that cold fusion is a nuclear process producing excess power from ordinary hydrogen and deuterium at room temperature, without commensurate amounts of nuclear reaction products, qualifies as pathological science.

JOHN R. HUIZENGA,

PROFESSOR OF CHEMISTRY AND PHYSICS AT THE UNIVERSITY OF ROCHESTER

Today, four years after the Utah news conference, only a handful of academic scientists in the United States are pursuing cold fusion. The only American experiments receiving any significant funding are those of Michael C.H. McKubre at SRI International, a nonprofit contract research institution in Palo Alto, Calif. McKubre's lab has been receiving $3 million to $4 million a year from the utility-supported Electric Power Research Institute to determine, one way or the other, whether nuclear reactions are occurring during the electrolysis of heavy water. (McKubre's experiments were interrupted for several months in 1992 when a sealed electrolysis cell suddenly overpressurized and exploded, killing one of McKubre's fellow workers.)

Other researchers, such as Storms at Los Alamos, electrochemist John Bockris at Texas A&M University, and physicist Robert Bush at California State Polytechnic University, are managing to keep their experiments going either through the use of discretionary funds at their disposal or with the financial help of private individuals.

Meanwhile, an unusual network of what might be called "cold fusioneers" has sprung up around the country. Thomas Droege, an engineer at the big federally owned Fermi National Accelerator Laboratory in Batavia, Ill., and Mark Hugo, a 39-year-old utility engineer in Minneapolis, are both running cold fusion experiments in their basements with their own money.

Jed Rothwell, a 38-year-old software developer in Chamblee, Ga., who lives off dividends from the software company that he founded 15 years ago, spends much of his time using his fluency in Japanese to act as an informal liaison between U.S. and Japanese cold fusion scientists. He often teams up with Eugene F. Mallove of Bow, N.H. Mallove is an engineer-turned-writer who quit his job as an information officer at the Massachusetts Institute of Technology (MIT) to write a book, *Fire from Ice*, espousing cold fusion (and castigating MIT physicists for not believing in it).

Rothwell and Mallove are among the principals of Clustron Sciences Corp., a Vienna, Va.-based company set up to explore some novel theories that physicist Ronald A. Brightsen claims explain cold fusion as well as a number of other "impossible" nuclear reactions.

In Salt Lake City, Harold L. Fox, a 69-year-old retired missile engineer, publishes a newsletter called *Fusion Facts*. He also has enlisted such scientists as Bockris at Texas A&M and Bush at California Polytechnic to join a small start-up company, Future Energy Applied Technology, or FEAT, that has scraped up $500,000 to finance cold fusion experiments.

The vacuum created by Washington's cold-shouldering of cold fusion is rapidly being filled by the Japanese. Late last year the Ministry of International Trade and Industry (MITI) committed three billion yen (about $25 million) over the next three years to what it gingerly calls "new hydrogen energy" research. Several million more are being poured into cold fusion by Japanese corporations.

The Japanese have even co-opted Pons and Fleischmann. The pair abandoned the University of Utah in late 1990 and moved their research to Sophia Antipolis, a suburb of Nice, France. There they were given laboratory space, equipment, and funding by IMRA Europe, the European arm of a research institute controlled by Toyota Motor Co.

The Japanese interest was ignited by an experiment by Akito Takahashi at Osaka University. In early 1992, he reported his electrolytic experiment had been continuously producing an average of 70 percent more heat than it was consuming in electric power. One trick, he said, was to "cycle" the input power, alternately running the current at high and low levels for minutes to hours.

Within a few months, Storms at Los Alamos replicated the Takahashi experiment, getting excess heat continuously for 295 hours before a component broke. He also found a hint of why some experiments work and others don't. With the help of Jed Rothwell, one of the cold fusioneers, Storms had obtained pieces of palladium from the same Japanese-produced batch of the metal used by Takahashi. Electron microscopy revealed that the piece of palladium that produced excess heat was relatively free of microscopic cracks; many such cracks suffused the surface of a second chunk of palladium that failed to produce excess heat.

Some researchers say they are on the verge of being able to tell others exactly how to reproduce an experiment that generates excess heat. In the fall of 1992, McKubre reported that 11 of the previous 12 experiments at SRI In-

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ternational had produced excess heat. Among several of the tricks of reproducibility, McKubre says, is the addition of aluminum or silicon to the heavy water electrolyte. The additions cause a mysterious sludgelike film to form on the palladium cathode, the role of which is unknown at present.

The amount of excess heat in the reproducible SRI experiments is small, ranging from 1 to 30 percent more than the electrical power put into the thermos-bottle-size electrolytic cells. Nevertheless, McKubre says, "the output power is larger than the input power and larger than the measures of uncertainty."

What remains unpredictable, he says, are the sudden and sporadic bursts of large amounts of excess heat. These bursts were what prompted Pons and Fleischmann to make their original claims, and they have since been seen in other experiments. The bursts in the SRI experiment may run for hours and produce excess heat equaling as much as 300 percent of the input power.

"As far as I'm concerned, there remains a mystery here that needs to be solved," says McKubre. "The excess heat isn't consistent with chemical or mechanical processes."

Other researchers say they are getting unmistakable evidence of nuclear reactions in Pons-Fleischmann types of experiments. Bockris at Texas A&M says he has detected tritium in the heavy water of at least one of his cold fusion experiments at levels as much as 10,000 times above background. Tritium is a triply-heavy form of hydrogen that can be created only by nuclear reactions. Tritium production also has been reported by researchers at the big Bhabha Atomic Research Center near Bombay, India.

Bockris also claims that the palladium rod from the tritium-producing experiment was found to contain 2 to 100 times more atoms of helium-4 than "control" rods from the same batch of palladium. Helium-4 can be produced by the fusion of deuterium and tritium.

Other reports of having detected small but inexplicable amounts of helium-4 in cold fusion experiments have come from researchers at the Naval Weapons Center in China Lake, Calif., the University of Texas, and the University of Hawaii.

Such claims, however, fall on deaf ears in the physics community. Cold fusion researchers have been unable to show that the production of helium-4 or tritium correlates with the production of excess heat. Thus they have lacked the one piece of incontrovertible evidence that would show the excess heat

[Continued on page 82]

A FUSION PRIMER

The quest for fusion energy—limitless and essentially nonpolluting—rests on basic nuclear physics. When two nuclei of heavy hydrogen, or deuterium, fuse, the combined masses of the fusion products are less by a minute amount than the mass of the original particles. But the conversion of this tiny mass results in a huge torrent of energy, because of Einstein's famous equation, $E=mc^2$; c is the speed of light.

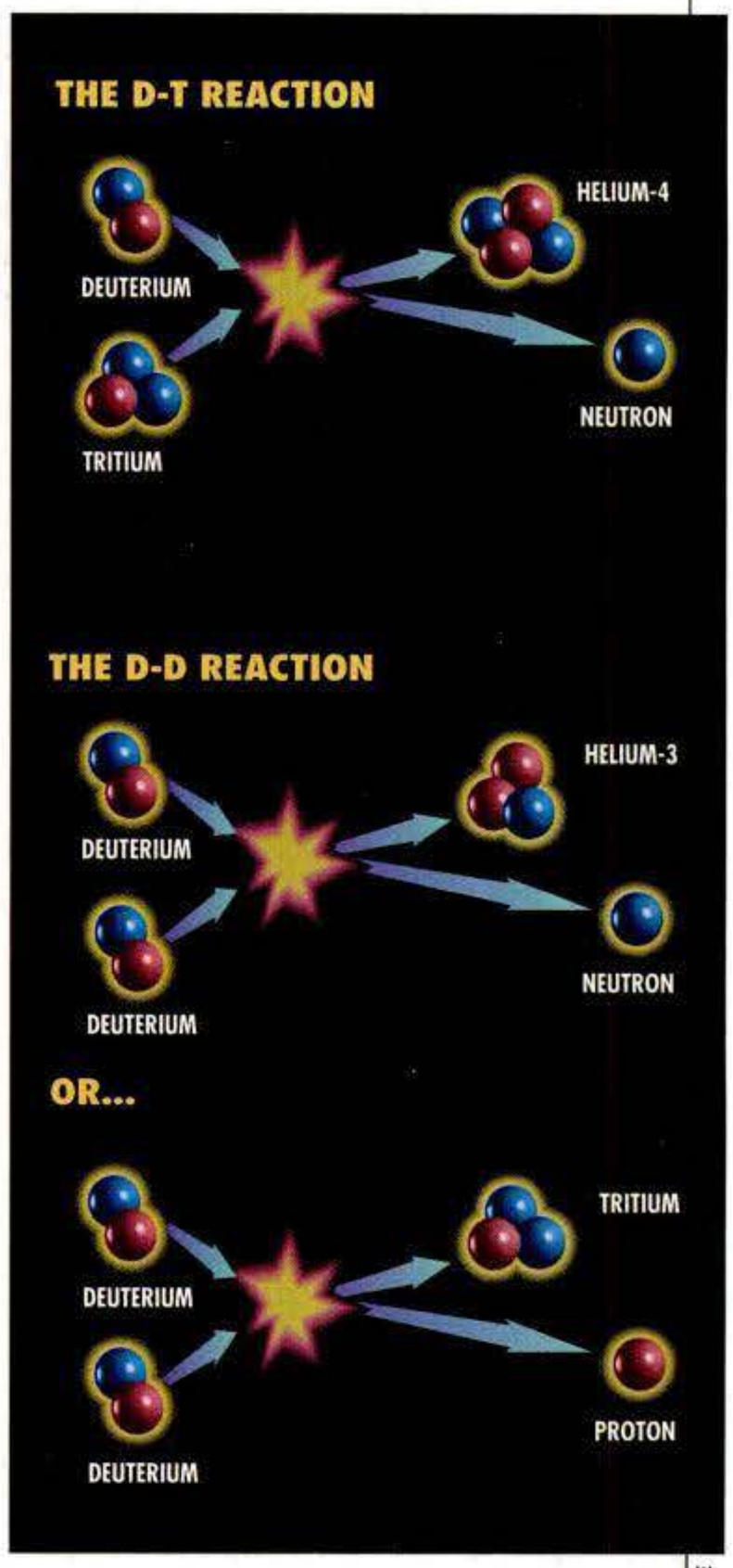
To get the positively charged deuterons to fuse (the D-D reaction) is a tremendous challenge. Deuterons are positively charged and are therefore mutually repelled by the electromagnetic force, which has an infinite range. The closer they approach one another, the stronger the repulsion, and the more energy is needed to overcome it. At one point this repulsive force reaches a maximum, called the Coulomb barrier. If this barrier can be penetrated, and the deuterons brought to within one ten-trillionth of a centimeter of each other, the strong nuclear force takes over (the same force that keeps atomic nuclei, with their cargo of positively charged protons, from flying apart), and the particles fuse.

The problem is to confine the deuterons long enough, at a high enough density (a combination called the Lawson criteria) and at a high enough temperature. At the center of the sun and other stars, enormous gravitational pressure provides the high-density confinement, and the temperature is 10 million degrees and more. On Earth, much higher temperatures are needed—100 million degrees for a deuterium-tritium, or D-T fusion reaction. The D-T reaction is the one now being pursued because it offers fewer technical difficulties than the D-D and yields more energy.

Tritium, like deuterium, is a heavy isotope of hydrogen, but its nucleus has a proton and two neutrons, rather than deuterium's proton and single neutron.

The telltale signatures of these reactions—the way an energetic process can be revealed as nuclear rather than chemical—are its end products, as seen in the graphics above. In D-T fusion, the reaction products are helium-4, neutrons, and energy. For D-D reactions, there are two branches, about equally probable. One yields helium-3, neutrons, and energy; the second yields tritium, protons, and energy. (A third, very rare D-D branch, about one in ten million, yields helium-4 and a torrent of gamma rays.)

Physicists have long contended that cold fusion experiments could not be considered conclusive without the simultaneous detection of helium, neutrons with the appropriate energy spectrum, and excess heat.—*Arthur Fisher*



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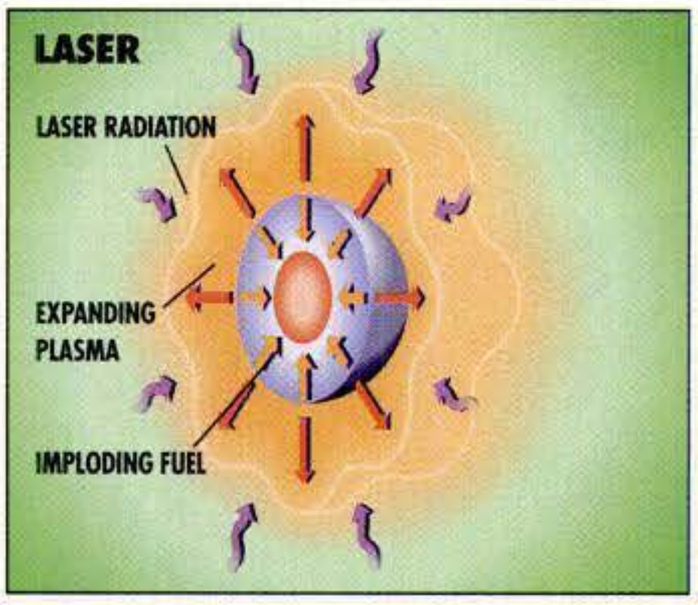

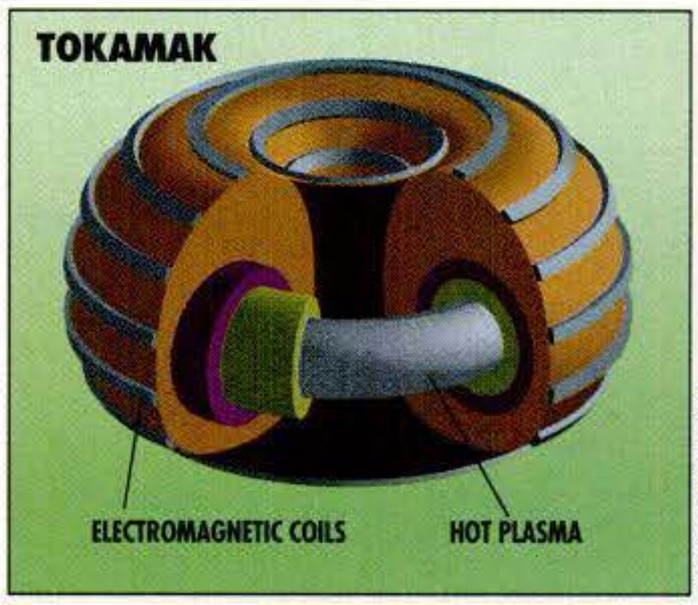

JARED SCHNEIDMAN

Magnetic confinement and laser confinement are two routes to "hot" fusion. Magnetic fields in the doughnut-shaped tokamak (above right) confine and squeeze a hot plasma so that deuterium and tritium ions can fuse. When laser beams symmetrically bombard a deuterium-tritium fuel pellet (above left) its outer layer vaporizes and flies outward. The reaction force implodes the fuel, causing fusion.

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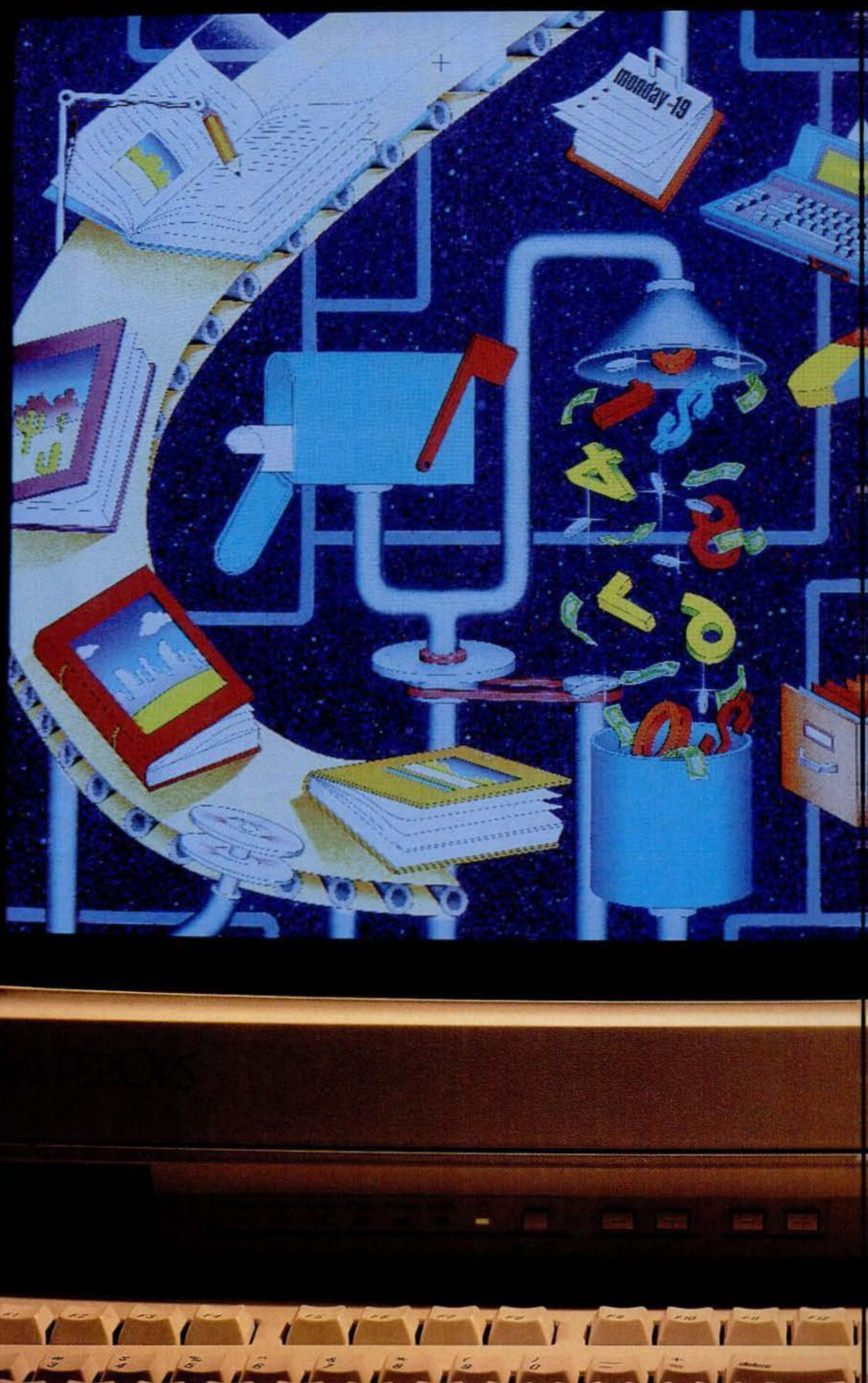
monday-19

The essential software that controls personal computers is undergoing major renovation.

BY CHRISTOPHER O'MALLEY

A NEW PERSONALITY FOR PCS

On the screen, the new operating systems for personal computers appear to be little more than collections of cute pictures and two-dimensional "windows" that frame works in progress. But beneath the colorful veneer are the nuts and bolts of a new generation of smarter, faster, and easier-to-use software. A small army of these new products is bidding for your attention—and your dollars.

If the microprocessor is the "brains" of a personal computer, then the operating system is its personality. An operating system is a layer of software that underlies application programs such as word processors and spreadsheets. Essentially, it serves as a stage director, coordinating the comings and goings of programs and data files while establishing a common backdrop for all of the activities that take place on the screen. In the process, the operating system plays a pivotal role in determining whether a PC is inviting or intimidating.

That role hasn't changed, but now there's a casting call for the position. Just as a battery of new microprocessors lets you pick the brains for your next PC ["Power Chips," July], the latest operating systems enable you to imbue it with a personality and a work ethic that suit your style.

Heading the audition list for IBM-compatible PCs is an entirely new version of Microsoft's best-selling Windows operating system dubbed Windows NT, plus an updated edition of IBM's OS/2 software called OS/2 2.1. Right behind them are SunSoft's Solaris and Next Inc.'s NextStep operating systems, which were previously available only on costly workstation systems designed for scientists and

ILLUSTRATION BY TIM McMARVEY / PHOTOGRAPH BY JOHN B. CARNETT

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engineers. As if that isn't enough, Novell, with its UnixWare, leads a cadre of companies offering more amiable versions of Unix, a powerful but traditionally cryptic operating system that has been around since the 1960s. (Solaris and NextStep are rooted in Unix as well.)

Still more are on the way. Apple and IBM are cooperating on a radically new operating system through a jointly owned company called Taligent. Separately, Apple plans to adapt its Macintosh interface for other types of computers, including IBM-compatible PCs. Microsoft, meanwhile, is preparing versions of MS-DOS and Windows that, after years of working in tandem, go their separate ways.

With the exception of DOS, all of these operating systems offer the visual ensemble of movable and sizable windows, point-and-click icons, and options-setting dialogue boxes collectively known as a "graphical user interface," or GUI. A GUI not only makes the software easier on the eyes, it makes programs easier to learn and use by forcing them to conform to a similar appearance and set of commands. By contrast, programs written for DOS generally have little in common beyond being loaded from the C:> prompt.

The appeal is more than screen deep, though. Most of these new products are 32-bit operating systems, which means they manage information from disks and memory in parcels as large as 32 characters, or four bytes of computer data. It's like having four lanes moving information instead of the two lanes now provided by 16-bit operating systems such as MS-DOS 6 and Windows 3.1. The extra software lanes are long overdue; most of the PCs sold in the United States since 1990 use 32-bit microprocessors.

The immediate impact of a wider highway is that programs run faster and can tap into larger amounts of memory and disk space. The more intriguing effects, however, will show up in the novel software that these 32-bit operating systems are likely to spawn. There's little doubt, for example, that more programs will feature photo-realistic images, full-motion video clips, stereo sound, and other multimedia effects. A bigger pipeline for communications activity should accelerate the merger of computer and telephone technologies, including desktop faxing and videoconferencing. Software should get "smarter" too. A daily planning program might track your habits and organize your days accordingly, for instance.

These new operating systems also have the dexterity to juggle several tasks at once, a capability often called multi-tasking. Using this feature, for example, you can type a letter or search through a database of customers while next year's budget numbers are still being recalculated in a spreadsheet. With many everyday chores, multi-tasking is a minor convenience. With bigger jobs, however, it can be an enormous time-saver.

Without a doubt, the most anticipated operating system of the recent introductions is Windows NT. But Windows NT, which stands for New Technology, could be more important as a precedent than a product. With its emphasis on sophisticated information-sharing features, Windows NT is aimed mainly at computer professionals who build the networks of PCs that help run many of today's larger corporations, schools, and government agencies. All of NT's other key features also are expected to appear in the next revision of Windows 3.1, which is slated for mid-1994 and is likely to be called Windows 4.0.

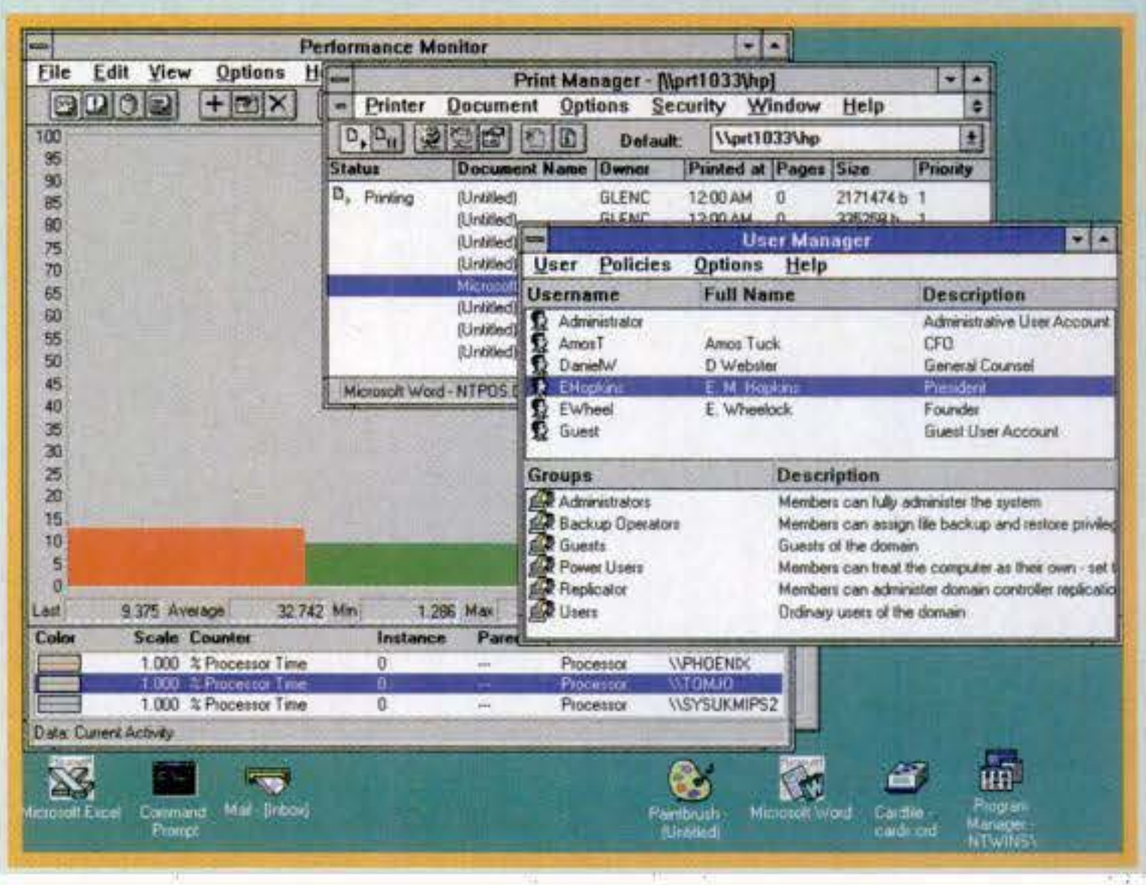
The biggest change in Windows NT and in the forthcoming 4.0 is that, unlike all previous versions of Windows, they do *not* require DOS to run. Windows NT and Windows 4.0 will be complete operating systems—sturdy new stages built from the ground up to support a revised cast of application players, not merely fresh coats of paint on an aging platform.

Few outward signs in Windows NT reveal its significant transformation from DOS mask to DOS replacement. NT looks the same as Windows 3.1 (the version now used by an estimated 25 million people) and can run the same DOS and Windows programs. But beneath the surface, much has changed. Windows NT is a 32-bit operating system, and already there is a rapidly expanding library of software that takes advantage of NT's broader avenues. Many of these programs will run under Windows 4.0, which is also a 32-bit operating system.

The most noticeable performance improvement in Windows NT may be its proficiency at multi-tasking, an aptitude Windows 4.0 should share. This capability has been available in a much more limited form in Windows for several years. Windows NT even opens the door for performing simultaneous tasks within a single program. A word processor might check your grammar as you type, for example, or a database might continuously arrange your records in alphabetical order as you add new information. This so-called "multi-threading" feature was not previously available in Windows.

The blossoming of Windows into a modern and self-sufficient operating system also means that it can more easily be converted to run on other types of computers. With DOS still underfoot, you could run Windows programs only on PCs using Intel processors or compatible chips. Windows

WINDOWS NT


Performance Monitor
File Edit View Options
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Printer Document Options Security Window Help
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User Manager
User Policies Options Help
Username Full Name Description
Administrator Administrative User Account
AmosT Amos Tuck CFO
DanielW D Webster General Counsel
EHopkins E. M. Hopkins President
EWheel E. Wheelock Founder
Guest Guest User Account
Groups Description
Administrators Members can fully administer the system
Backup Operators Members can assign file backup and restore privileg
Guests Guests of the domain
Power Users Members can treat the computer as their own - set t
Replicator Members can administer domain controller replicatio
Users Ordinary users of the domain
Last 9.375 Average 32.742 Min 1.286 Max
Color Scale Counter Instance Parent
1.000 % Processor Time 0 Processor \\PHOENIX
1.000 % Processor Time 0 Processor \\TOMJO
1.000 % Processor Time 0 Processor \\SYSUKMIPS2
Data: Current Activity
Microsoft Excel
Command Prompt
Mail - (Inbox)
Paintbrush - (Untitled)
Microsoft Word
Cardfile - cards.crd
Program Manager - NTWIN51

LIST PRICE: $495 / UPGRADE PRICE: $295

Windows NT represents the next generation of Microsoft's Windows operating system and paves the way for next year's more mainstream version, Windows 4.0. Windows NT can run existing DOS and Windows software, plus new or updated Windows programs that take advantage of NT's speed and networking features.

ADVANTAGES: runs DOS and Windows software; common graphical interface; does not require MS-DOS; 32-bit speed; multi-tasking; not specific to Intel-compatible PCs

DRAWBACKS: more complex than Windows 3.1; 486-class or faster PC recommended; requires a lot of memory and disk space; cannot run graphical OS/2 software; has no track record of reliability

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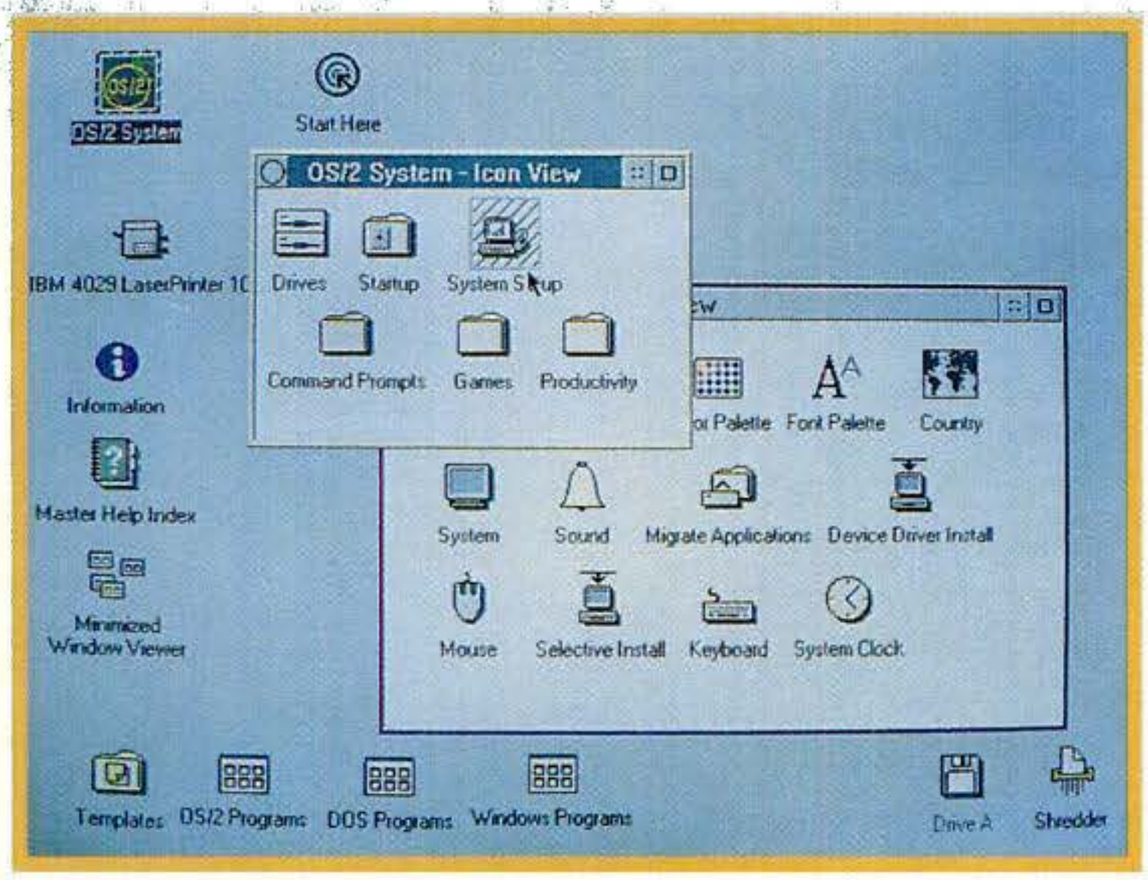
OS/2 2.1



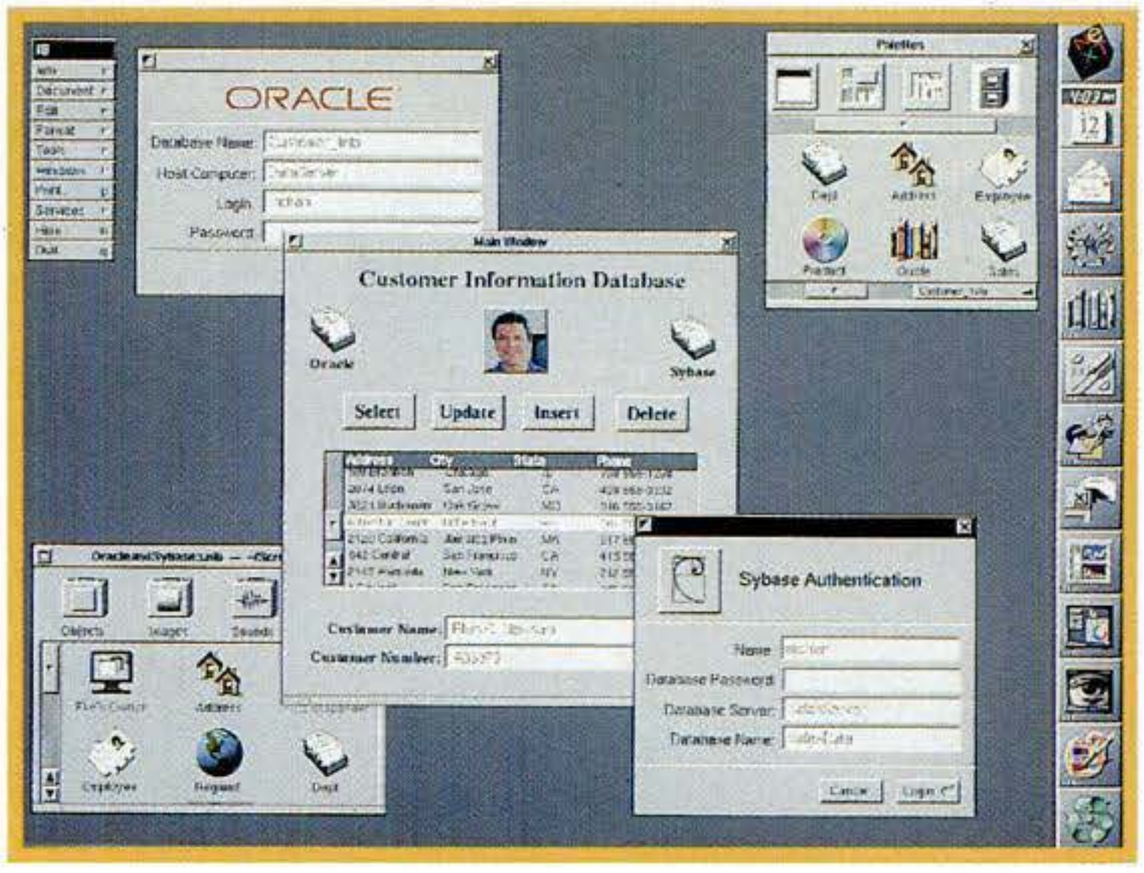
LIST PRICE: $249 / UPGRADE PRICE: $119

IBM's OS/2 operating system is the most popular alternative to MS-DOS and Windows and includes many of the features found in Windows NT. Version 2.1 of OS/2 adds support for high-resolution graphics and the ability to run Windows 3.1 programs, in addition to OS/2 software. OS/2 can also run MS-DOS programs

ADVANTAGES: runs DOS, Windows, OS/2 software; common graphical interface; multi-tasking; fast 32-bit performance; proven reliability

DRAWBACKS: relatively few OS/2 programs; won't run new 32-bit Windows software; tied to PCs with Intel-compatible chips; requires 386-class or faster PC; must have 4MB or more of memory

NEXTSTEP



LIST PRICE: $795

Originally conceived for Next Inc.'s own computers, which have been discontinued, NextStep moves to the IBM-compatible world with NextStep for Intel Processors—specifically, for 486 and Pentium processors. As yet, only a modest selection of software has been written for NextStep, but they are mostly first-rate programs.

ADVANTAGES: elegant graphical interface; many information-sharing features; multi-tasking; fast 32-bit performance; e-mail and network functions included

DRAWBACKS: expensive; few NextStep programs; doesn't run Windows software; requires 486 or Pentium PC; 16MB memory and 120MB hard disk minimum

NT runs on those PCs, but it can also run on computers built around entirely different chips. Versions of Windows NT are already available for PCs employing Digital Equipment Corp.'s Alpha processor, as well as MIPS Technologies' R4400 chip. A version of NT for the PowerPC processor developed by IBM, Apple, and Motorola may be in the works as well. Some of the personal computers equipped with these new chips are apt to be faster and less expensive than similar models using Intel's latest chip, the Pentium processor. Windows 4.0 should give you similar options, though there is no guarantee that it will be adapted for these new processors.

While all of these new features and options make Windows NT a tempting step forward, there are reasons to wait or choose an alternative. Due in part to its many network-building features, Windows NT requires a PC with a microprocessor that's at least as fast as an Intel 386DX running at 25 megahertz (MHz), and many experts consider a 486-class chip to be a more realistic minimum. You will also need 12 megabytes (MB) or more of memory—six times the minimum for Windows 3.1—and a hefty 70MB in hard disk space just to store the operating system, let alone application programs. Windows NT itself costs $495.

Windows 4.0, on the other hand, almost certainly will be less costly and require less hardware than Windows NT, according to Jesse Berst, publisher of *Windows Watcher*, an industry newsletter based in Microsoft's hometown of Redmond, Wash. "Windows 4.0 will be the operating system of choice for everyday computing," says Berst.

Windows 4.0 might also incorporate the electronic mail and group scheduling features that are now contained in a version of Windows 3.1 called Windows for Workgroups.

The future of MS-DOS is somewhat less clear, though Microsoft has already told software developers that there definitely will be an MS-DOS 7 (perhaps introduced at the same time as Windows 4.0). Like the current version, DOS 6, DOS 7 will not have a graphical interface. But, for the first time, it *is* expected to let you run several programs at once. (Meanwhile, many people continue to use earlier versions of DOS. One incentive for switching to 6 is a data-compression feature that can double your hard disk space.)

But waiting for a future version of DOS or Windows is not your only alternative to Windows NT. IBM's OS/2 is a complete 32-bit operating system with a built-in graphical interface similar to that of Windows. OS/2 also has the same sort of multi-tasking and multi-threading features found in Windows NT. And OS/2 runs not only applications written for it, but those written for DOS and Windows too. It has had all of these features since the release of version 2.0 early last year.

Despite its head start on Windows NT and its superiority to earlier versions of Windows, OS/2 remains an underappreciated operating system. Mostly, that's because far fewer programs are available for OS/2 than for Windows, and the majority of OS/2 titles are programs tailored for specific businesses, not general-purpose software. That's slowly changing, however; Lotus plans new versions of 1-2-3, Ami Pro, and Freelance Graphics for OS/2, for example, and WordPerfect is rewriting its namesake word processor for OS/2. But it's still true that the breadth and depth of Windows programs far surpass that of OS/2 software.

The new release of OS/2, version 2.1, illustrates the dilemma. OS/2's speed and reliability—already strong points—are much improved in this edition. But its principal new feature is the ability to run programs originally written for Windows 3.1, which was introduced a year earlier. Previously, OS/2 ran only programs written for Windows 3.0, the

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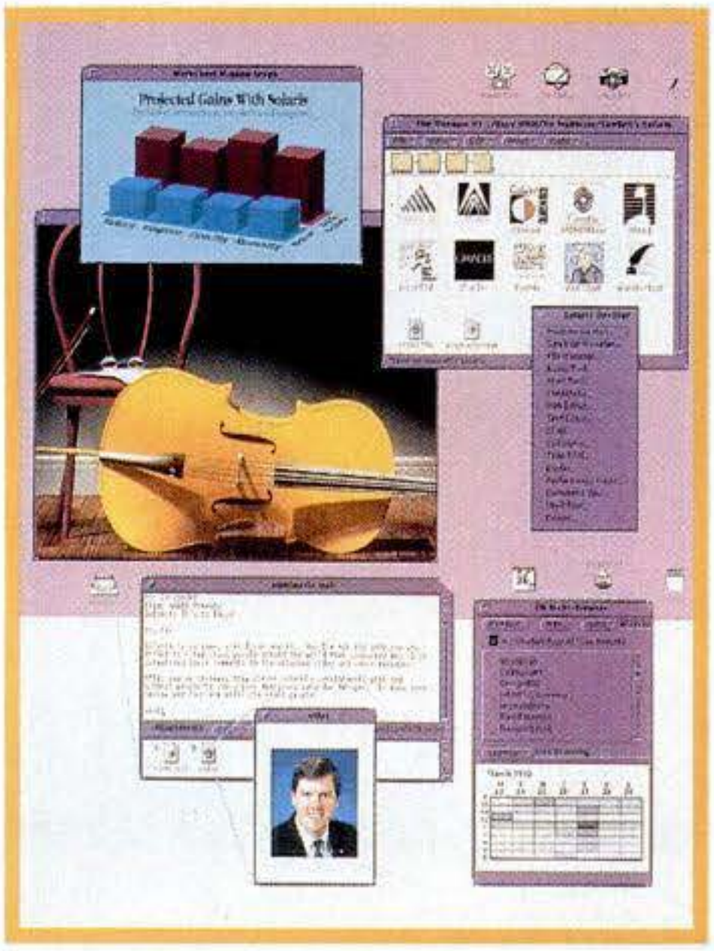
A GUIDE TO THE NEW OPERATING SYSTEMS

SOLARIS



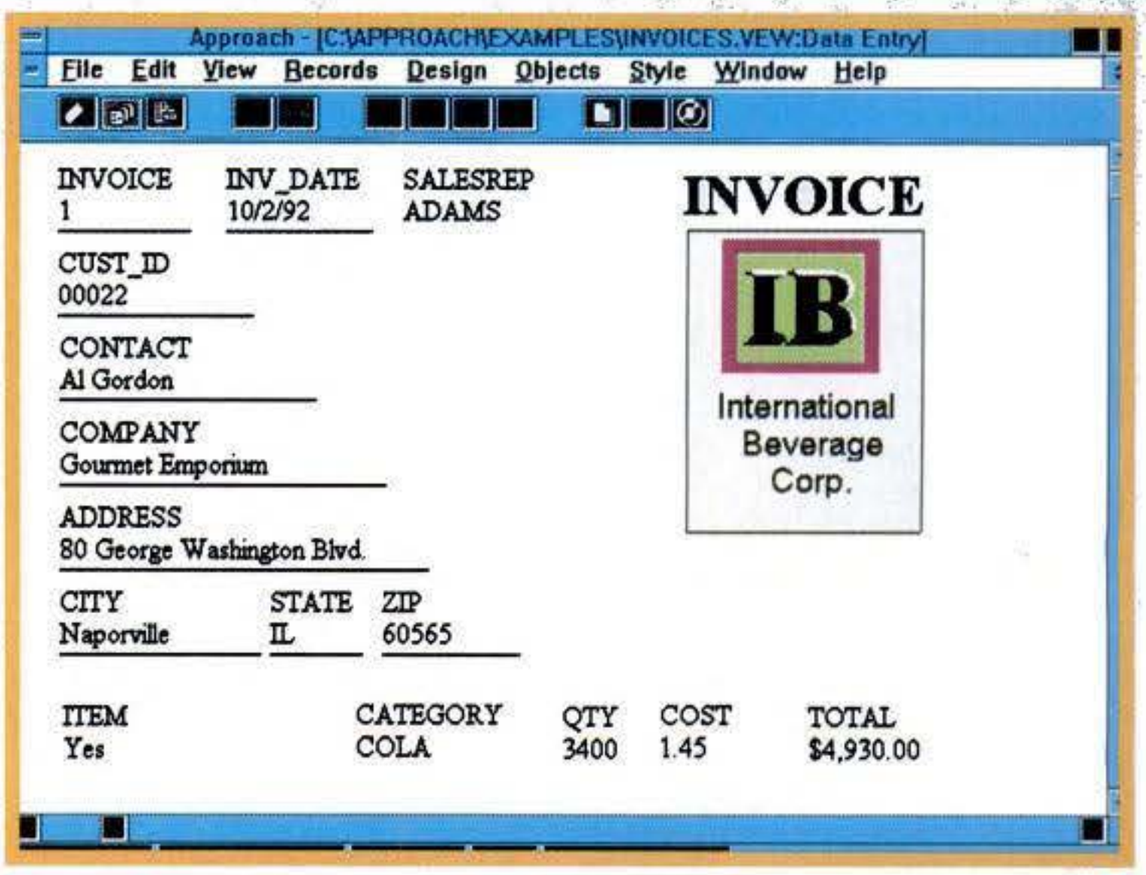
LIST PRICE: $795

SunSoft's Solaris x86 is virtually identical to the Solaris operating system used in the technical workstations sold by parent company Sun Microsystems. Much of the software written for those workstations is being adapted for this IBM-compatible version, and a software technology called Wabi may enable Solaris to run DOS and Windows programs as well.

ADVANTAGES: graphical interface; compatible with Sun workstations; multi-tasking; fast 32-bit performance; many networking features

DRAWBACKS: expensive; runs mostly technical Unix programs; DOS and Windows compatibility unproven; requires 486 or Pentium PC; 12MB memory and 200MB hard disk minimum

WINDOWS 3.1



LIST PRICE: $149 / UPGRADE PRICE: $79

Microsoft's Windows 3.1 is the prevailing standard in graphical interfaces for PCs running MS-DOS. Thousands of popular programs, such as Excel, PageMaker, and Word, are now available for Windows. Many older DOS programs, including Lotus 1-2-3, WordPerfect, and Paradox, have been adapted to run within Windows too.

ADVANTAGES: broad software selection; easy-to-use graphical interface; programs share common look and commands; can swap information between programs; built-in fonts for any printer

DRAWBACKS: still requires MS-DOS; 16-bit design not optimal for 32-bit PCs; only for PCs with Intel-compatible chips; slow, limited multitasking; requires 386 or faster PC

1990 version. Buying OS/2 to run Windows programs, therefore, will often leave you behind the times. For running a mix of OS/2, Windows, and DOS programs, however, OS/2 is the only choice. And OS/2, which lists for $249 and requires a minimum of 4MB of memory, can run all three types simultaneously.

Eventually, IBM says it plans to fold OS/2 into an operating system called Workplace (which is what the company now calls its graphical interface). Workplace will run OS/2, Windows, DOS, and Unix programs, as well as software written for the forthcoming Taligent operating system. Unlike OS/2, Workplace won't be tied to Intel microprocessors or compatible chips.

The Taligent operating system (code-named "Pink") being developed by IBM and Apple is not due until 1994 or even 1995, but its claim to fame is no secret. Taligent will be the first operating system to be made up entirely of distinct collections of software instructions called objects. An "object-oriented" operating system should make the process of creating new programs dramatically faster, because common procedures are defined as reusable building blocks. It's akin to building a house from prefabricated sections rather than individual pieces of wood. Taking the tedium out of "building" software, it's hoped, will leave programmers more time to be innovative.

The objects approach is already being used to a large extent by NextStep. Until recently, the NextStep operating system was being used only on Next's workstations. Next is no longer in the hardware business, instead trying to expand the appeal of NextStep to more popular PCs. In addition to a graphical interface that is possibly the most elegant to date, the Unix-rooted NextStep has a variety of intriguing features. Among them: a multimedia electronic-mail facility that lets you include color pictures and CD-quality sound with your messages, and a "digital librarian" for easily indexing and searching through text files.

Like Windows NT, NextStep for Intel Processors has many more features that are geared toward computer professionals. At $795, NextStep isn't cheap, either. Nor can you use it on an inexpensive system. NextStep requires a 486- or Pentium-based PC with 12MB or more of memory and 120MB of disk space just for the operating system. Nonetheless, several PC makers—including Dell, Epson, Hewlett-Packard, and NEC—are offering NextStep as an option with their machines.

SunSoft's Solaris x86 is another attempt to bring what has been a private-label Unix operating system into the mainstream. SunSoft is a division of Sun Microsystems, which manufactures topflight PCs, or workstations, for scientists and engineers. Until now, Solaris ran only on these machines. Solaris x86 works with PCs built around Intel chips, though it requires the same sort of costly hardware as NextStep. Solaris lists for $795. AST, CompuAdd, Toshiba, Zenith Data Systems, and others plan to sell PCs with Solaris x86.

In a broader effort to close the gap between Unix systems and standard PCs, Sun recently introduced a technology called Wabi that the company says will enable Solaris and other versions of Unix to run Windows programs without any modifications. Novell's UnixWare and Santa Cruz Operation's Xenix operating systems should be among the first to incorporate the Wabi software.

The most noteworthy new foray into the DOS and Windows arena, however, might come from none other than Apple. The company is reportedly working on a product that would combine the Macintosh's graphical interface with an MS-DOS clone from Novell called DR-DOS, extending the

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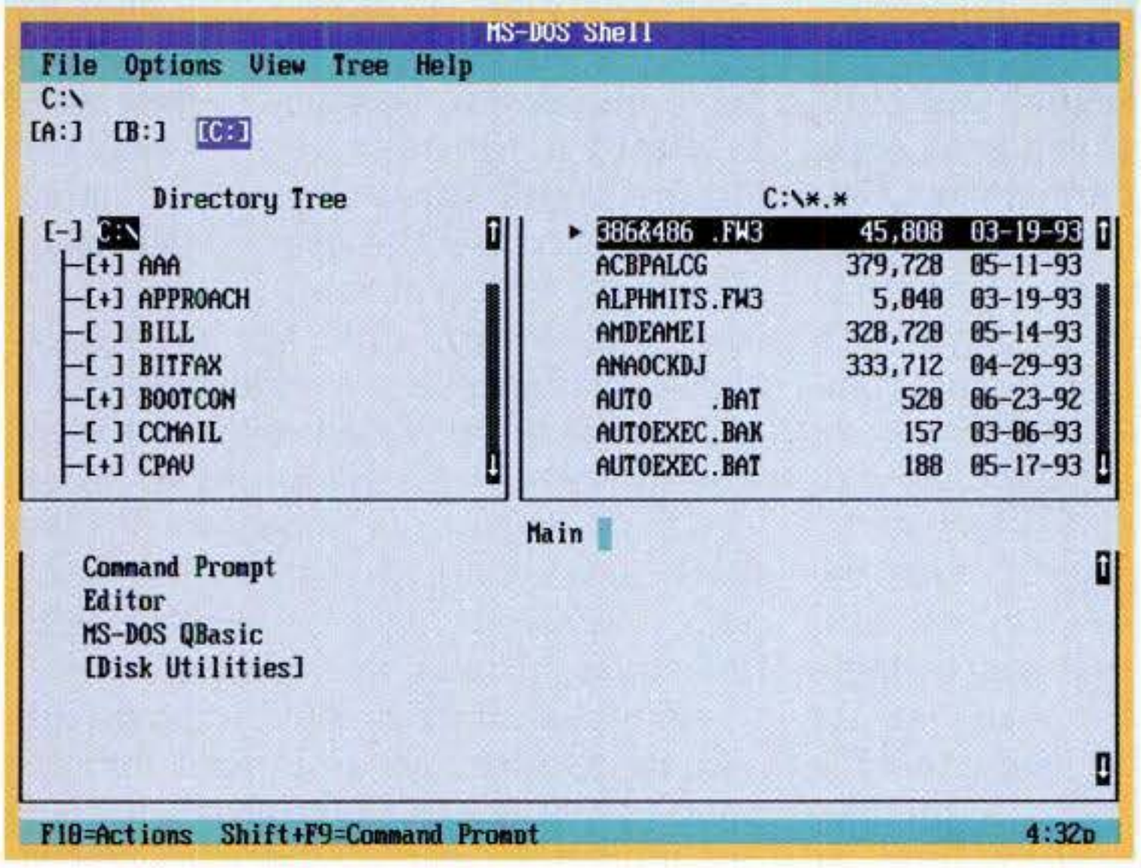
MS-DOS 6



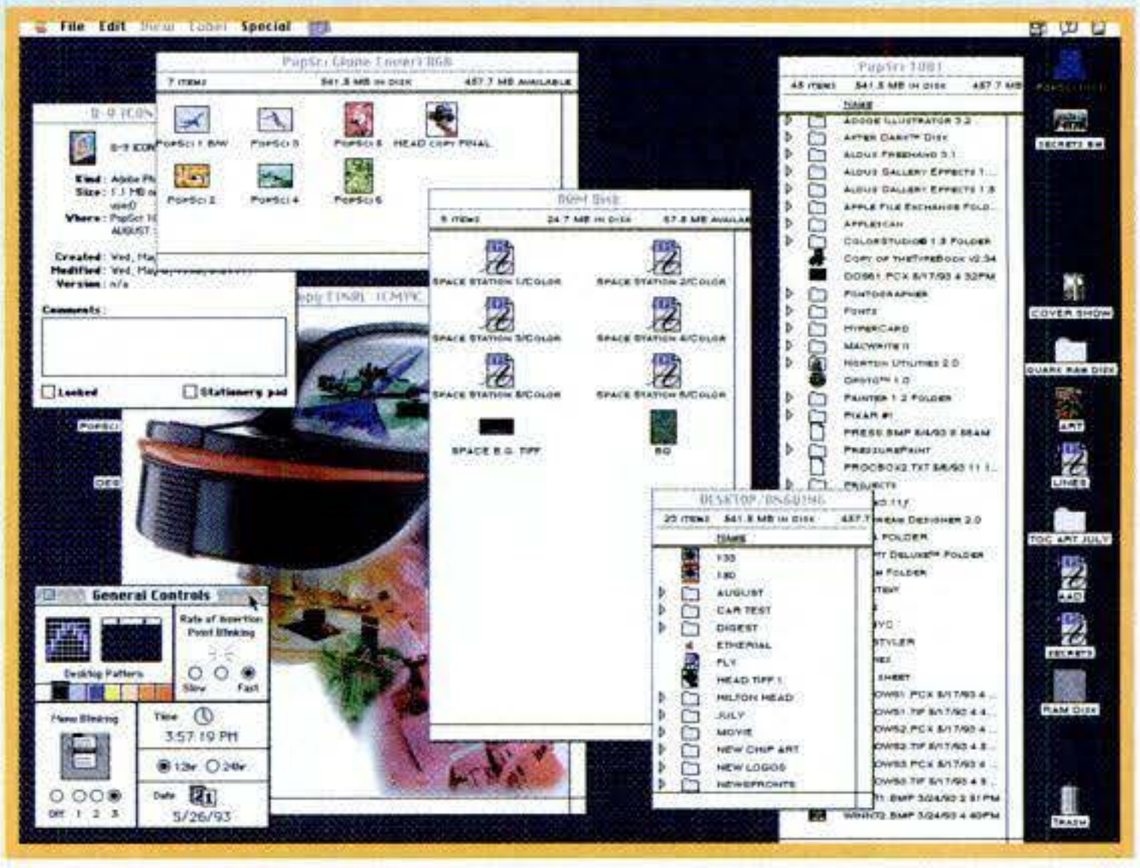
UPGRADE PRICE: $129

Microsoft's MS-DOS is the most widely used operating system in the world, running on more than 100 million IBM-compatible PCs. There are tens of thousands of programs written for DOS, including best-sellers such as WordPerfect and Lotus 1-2-3. DOS 6 adds data-compression, file-backup, and virus-checking features.

ADVANTAGES: offers a broad software selection; runs on any type of IBM-compatible PC; requires only 512K of memory; can double available hard disk space; backs up files, checks for viruses

DRAWBACKS: no common graphical interface; programs use different commands; only for PCs with Intel-compatible chips; no data sharing or multi-tasking; few new programs being developed

MACINTOSH SYSTEM 7.1



LIST PRICE: $99 / UPGRADE PRICE: $35

The first popular graphical operating system for desktop PCs, the Macintosh's System software hosts a collection of programs that are second only to Windows in quantity—and perhaps second to none in quality. System 7.1 is only available for Mac models, but Apple may soon bring it to IBM-compatible PCs.

ADVANTAGES: large software selection; refined graphical interface; installed on every Macintosh; 32-bit performance, multi-tasking; multimedia software included

DRAWBACKS: doesn't run DOS or Windows software; works only with Apple computers; runs slowly on older Macs; 4MB to 8MB of memory recommended

Mac's much-praised look and feel to Intel-based PCs. Such a combination would, among other things, make it easier to develop identical software capable of running on both Macs and PCs. Apple won't comment on the product, but outside sources suggest it could be released sometime this year or early next.

Apple is already in the process of moving the Mac interface to a new Unix-like operating system called PowerOpen, which will be used with future Macintoshes built with the PowerPC chip. The first of these Macs are expected to be available early next year.

While they take many different forms, all of these operating systems have one thing in common: They are powerful and colorful software launching pads that still manage to seem down-to-earth. That should make for an interesting, if somewhat crowded, trek toward computing's future. PS

MIGHTIER THAN THE MOUSE?

Whether you use a keyboard to type in commands or a mouse to point and click on menu selections, an operating system plays a key role in determining how you interact with a PC. The same holds true with computers that employ a much more ancient input device: the pen. But a pen fundamentally changes the rigid rules normally adopted by computer interfaces, and the advent of pen-based PCs has prompted a new breed of operating systems.

Pens are used in a wide variety of mostly portable computers. They include "tablet" models such as Grid Systems' GridPad, "personal digital assistants" like Apple's Newton, and "personal communicators" such as EO Inc.'s Model 440. In some cases, including the Newton, these devices use custom operating systems that are not available for other types of computers. But most pen-based computers use a more general-purpose pen operating system, such as Go Corp.'s PenPoint, Microsoft's Windows for Pen Computing, Communication Intelligence Corp.'s PenDOS, Grid's PenRight, and GeoWorks's Pen/Geos.

Like conventional operating systems, pen operating systems are both traffic cops and interior decorators, managing the flow of information between the software and hardware while establishing a common visual interface so that programs look and act similarly. But the interface must be geared to accept pen strokes rather than keystrokes or mouse motions for selecting menu items, scrolling through text, moving between documents, and other routine tasks. Pen operating systems also have to do something normal operating systems don't: convert handwritten marks into perfectly formed words and numbers, or at least be able to store them as "ink" scribblings that can be filed and retrieved as needed.

Of these new operating systems, PenPoint is the only one that was designed from the ground up as a pen-based operating system. (Windows for Pen Computing is a modified version of Windows, while PenDOS, PenRight, and Pen/Geos are pen interfaces that sit on top of MS-DOS.) As a result, PenPoint is *not* compatible with the thousands of programs written for DOS and Windows, though it can use data files from many of those programs. But PenPoint has a small and growing library of programs written especially for it, and its handwriting-recognition capabilities are often cited as the most accurate of the group. PenPoint also makes the fullest, most natural use of the pen. Its interface mimics a notebook with a table of contents and tabbed dividers. Touching one of the tabs with the pen, for example, brings you to that section of the notebook.

Depending on the computer you choose, the pen operating system may already be decided for you. Increasingly, however, you have your pick of operating systems with pen-based systems—just as you do with your penless PC.—*C. O.*

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Drug developer Dr. Michael Zasloff rolls his sleeve up to his elbow, plunges his hand into an aquarium, and pulls out a three-inch-long freckled green frog. He's standing in his lab at Magainin Pharmaceuticals in Plymouth Meeting, Pa., the company he formed to commercialize the discovery he's about to show me.

Wedging the frog between his thumb and fingers so it won't wiggle away, he pokes at its skin with the cap of a pen. Slowly, a puslike secretion oozes from its pores. "See that white stuff?" he asks. "That's an antibiotic. The frog's scared, so it's secreting antibiotics. My hand is probably sterile now."

The "white stuff" sure doesn't look like much, but it may turn out to be one of the greatest drug finds in decades. It's called magainin (Hebrew for "shield"), and it's one in a class of powerful new antibiotics that Zasloff and a few scientific wizards are finding in an unexpected place: animals. Not only in frogs, but also in sharks, moths, pigs, even jellyfish.

Ever since Alexander Fleming isolated penicillin from a common bread mold in 1929, pharmaceutical companies have focused their search for new medicines on microorganisms. Their efforts have produced wonder drugs like streptomycin and tetracycline. But recently, an alarming number of diseases, including strains of tuberculosis and gonorrhea, have mutated to become resistant to virtually all known antibiotics. The U.S. Centers for Disease Control, for example, says that in early 1991, the latest date for which figures are available, fully 14 percent of the reported cases of tuberculosis were resistant to one or more drugs. Moreover, traditional medicines have never worked that well against many ailments, such as certain skin infections, viruses, and cancers.

Animal antibiotics could improve the situation. Although unproven for human use, in the test tube they wipe out an unusually wide array of microbes —not only bacteria, but also protozoa, fungi, and yeast infections. More important, because they work differently from conventional drugs, animal antibiotics may be able to combat drug-resistant diseases.

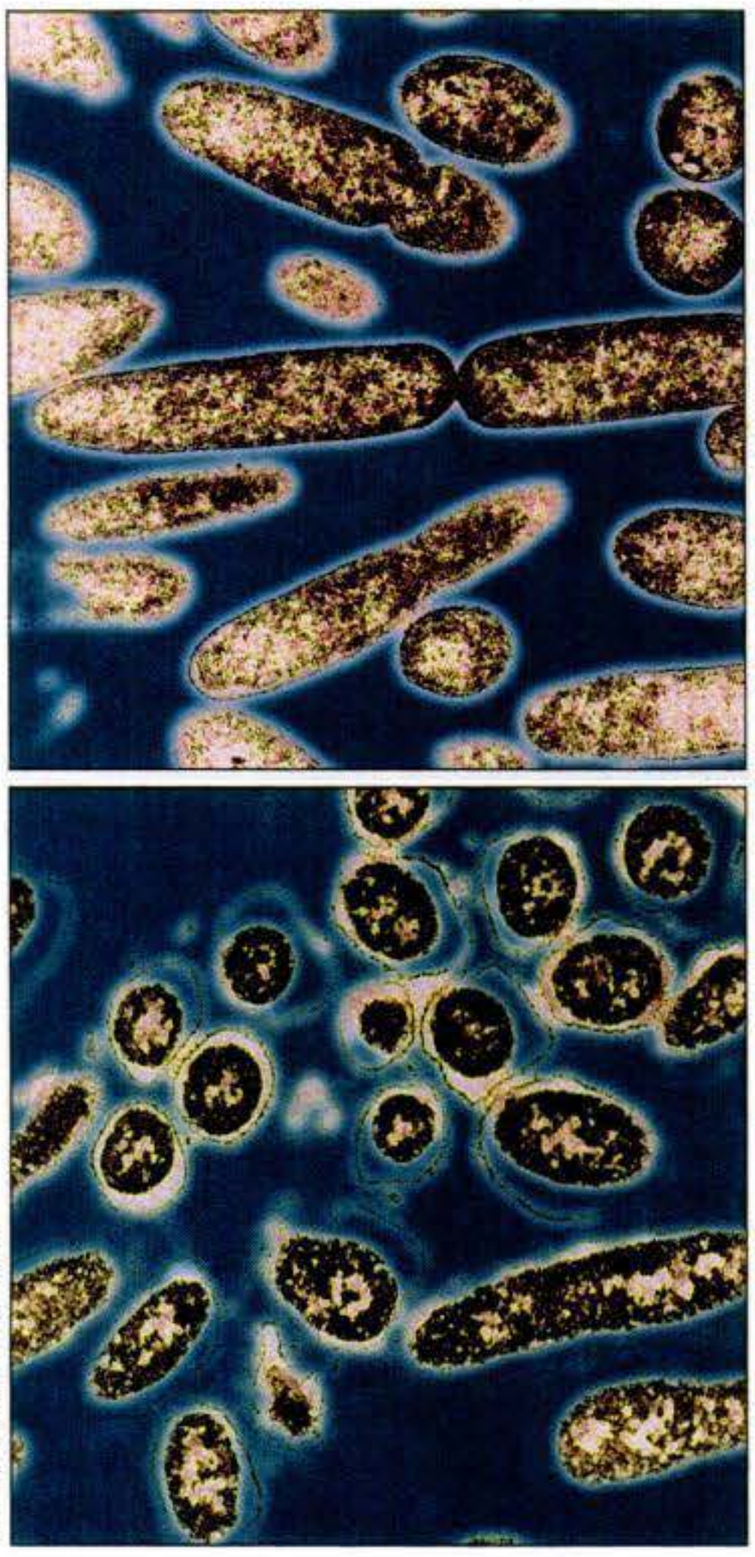
Even cancer, the bane of modern medicine, may fall before these antibiotics: In preliminary tests, one of Zasloff's magainins destroyed skin cancer cells, but left normal cells intact. This stands in contrast to today's chemotherapy treatments, which also ravage healthy cells.

Why are these animal chemicals so potent? Hundreds of millions of years ago, scientists believe, the first multicellular organisms emerged from a primordial soup that was filled with germs.

"For even the [simplest animals] to evolve," explains Zasloff, "they needed built-in defenses—magic bullets—to prevent themselves from being destroyed. It's these magic bullets we are beginning to find today."

For centuries, folklore has attributed magical powers to brews concocted

[Continued on page 78]



MAGAININ PHARMACEUTICALS

Top: Healthy *Pseudomonas aeruginosa*, which can cause skin and lung infections, swim in a petri dish.
Above: Fifteen minutes later, the once-dangerous bacteria are dead, their cell membranes dissolved by a dose of magainin, an antibiotic derived from animals.

Protected by a natural antibiotic, these amphibians won't catch any germs from Michael Zasloff.

How do you kill diseases that have become resistant to drugs? The answer may be found in frogs, sharks, and other animals.

Treat

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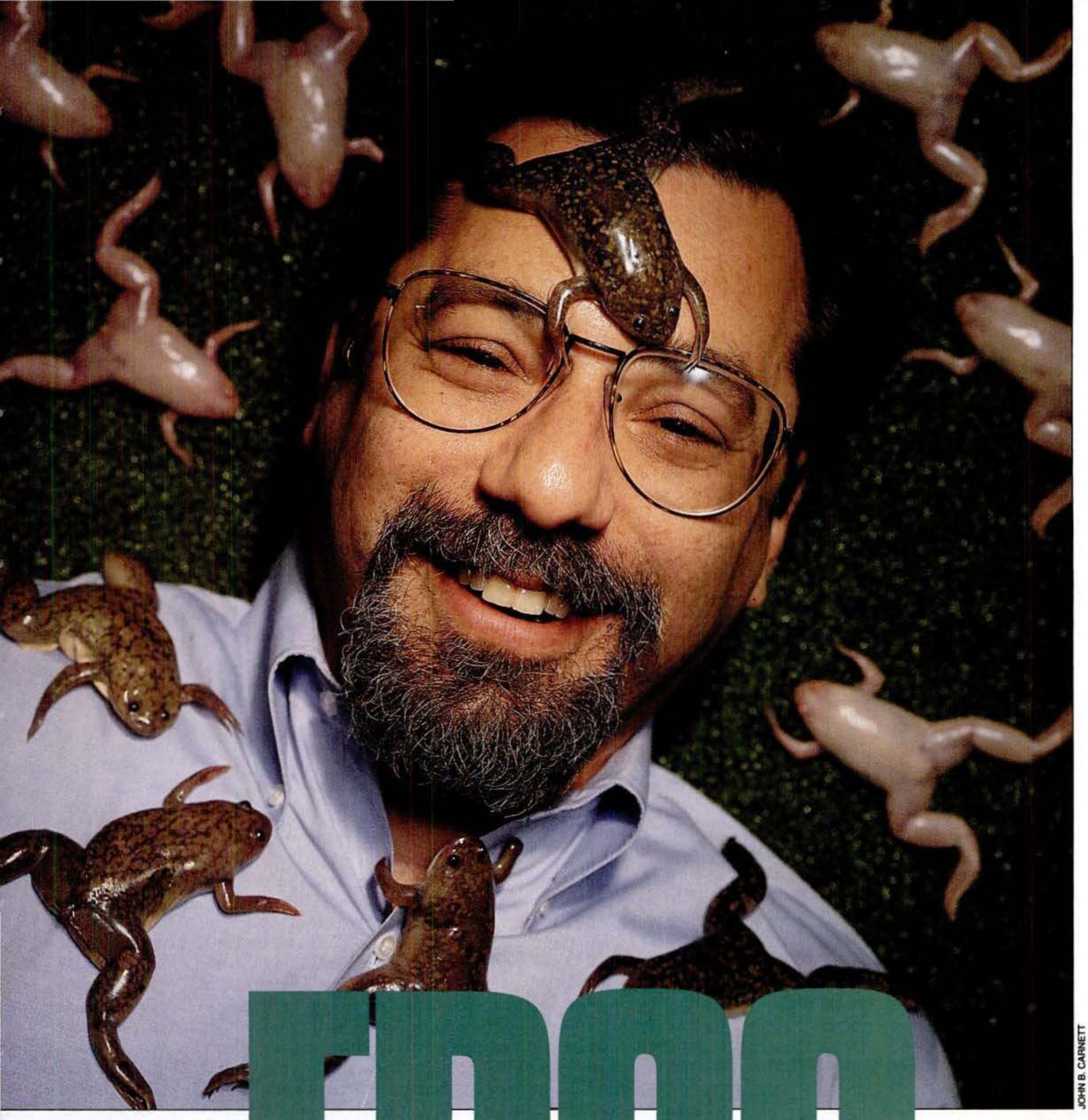

JOHN B. CARNETT

The FROGment

BY ROBERT LANGRETH

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The Electric EYE

A light-sensitive chip grafted to the human retina promises rudimentary vision for some people who cannot see.

BY MIKE MAY

No available surgery can yet restore Harold Churchie's vision. Churchie suffers from retinitis pigmentosa, a hereditary disease that progressively destroys photoreceptors, the cells in the retina that sense light. Yet, last year at the age of 64 he agreed to an operation at Duke University's Eye Center in Durham, N.C., in a bid to make a contribution, at least, to medical technology.

While Churchie kept still on the operating table, Dr. Eugene de Juan inserted a fine probe into Churchie's eye. De Juan maneuvered the probe through a one-millimeter cannula, a metal tube providing a tunnel into the eye's interior. The probe contained two thin wires—each about as thick as a human hair—and a fiber-optic light. Watching through a microscope aimed at the pupil of Churchie's eye, de Juan eased the probe against the retina, which occupies the back of the eye.

With the probe in place, the experiment began. Would Churchie "see" something if his retina was electrically stimulated? Neurons, signal-carrying cells of the nervous system, transmit information via electrical currents throughout the body. The cells can be excited—in effect, switched on—by an external electrical signal. De Juan's idea was to apply a little "shock therapy" to the cells.

The stimulus to Churchie's retina came from a rack of computer-driven instruments under the control of Dr. Mark Humayun, resident in ophthalmology at Duke, and Dr. Roy Propst, professor of biomedical engineering at the University of North Carolina at Chapel Hill. Churchie saw nothing during the first stimulus. So Humayun and Propst turned up the current repeatedly in fine increments. Finally, Churchie did see something. He described it as a "small pea," and he motioned with his hand, indicating that the pea was about 12 inches from his eye. Though there was no external light, the electrical stimulus had tricked Churchie's visual system, creating the sensation of vision.

One week later, the team repeated the procedure on 33-year-old Allen Dillis. "That's great!" Dillis exclaimed shortly after the stimulation began. He too experienced the sensation of light.

The experiments with Churchie and Dillis seem like nothing less than science fiction. They were early steps in a project intent on placing a tiny electronic device in a blind person's eye, thereby creating sight. The degree of

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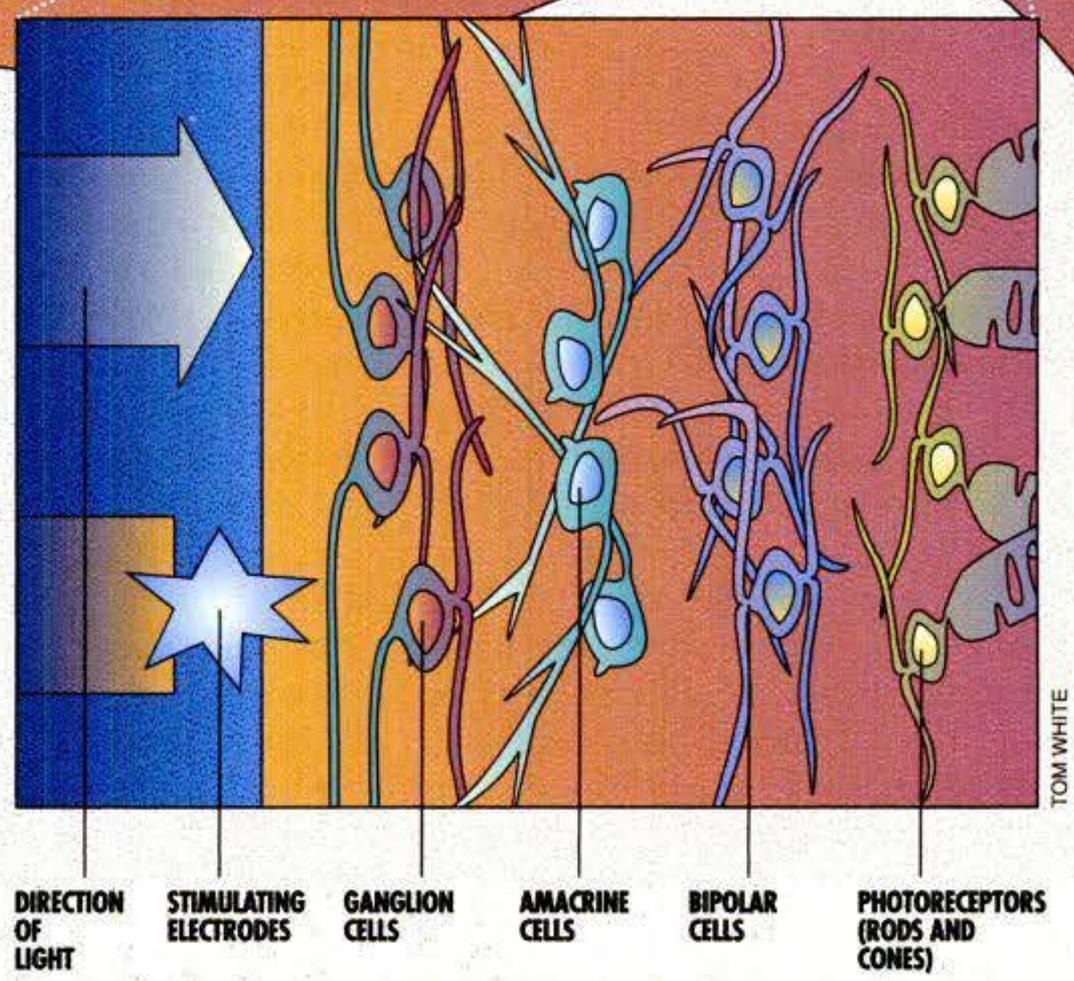
sight that would result remains uncertain. The first devices may provide only a sense of dark and light. But, in theory, such a device could produce a quality image, helping about 20,000 Americans who are blind because they lack functional photoreceptors. A detached retina, similar to retinitis pigmentosa, can also cause the destruction of the photoreceptors.

The type of visor and implant technology that enables the blind Le Forge (actor LaVar Burton) to see on "Star Trek: The Next Generation" still belongs to the future, but de Juan, now at the Wilmer Eye Institute at Johns Hopkins Hospital in Baltimore, says the human experiments were "a very exciting development because, in patients without photoreceptors, we were able to stimulate a focal and localized sensation of light."

The project began about five years ago when two scientists, one far from expert in biology, the other equally limited in miniaturized electronics, met on a back porch at a neighborhood party. De Juan soon found himself in animated conversation with his host, Dr. Howard Phillips of the Semiconductor Research Corp. in Research Triangle Park, N.C.

Phillips inquired about artificial-vision systems and asked if light sen-

HOW THE ELECTRIC RETINA WORKS



A light-sensing array of photocells implanted in the eye would capture entering light, convert the image to an electronic signal, and transfer the signal to the retina. In normally sighted people, an image is captured by the photoreceptors at the back of the retina, passed along a chain of cells toward the front of the retina, and carried to the brain by the ganglion cells (see inset). The artificial retina bypasses the photoreceptors by directly stimulating the surface of the retina, which turns on the ganglion cells.

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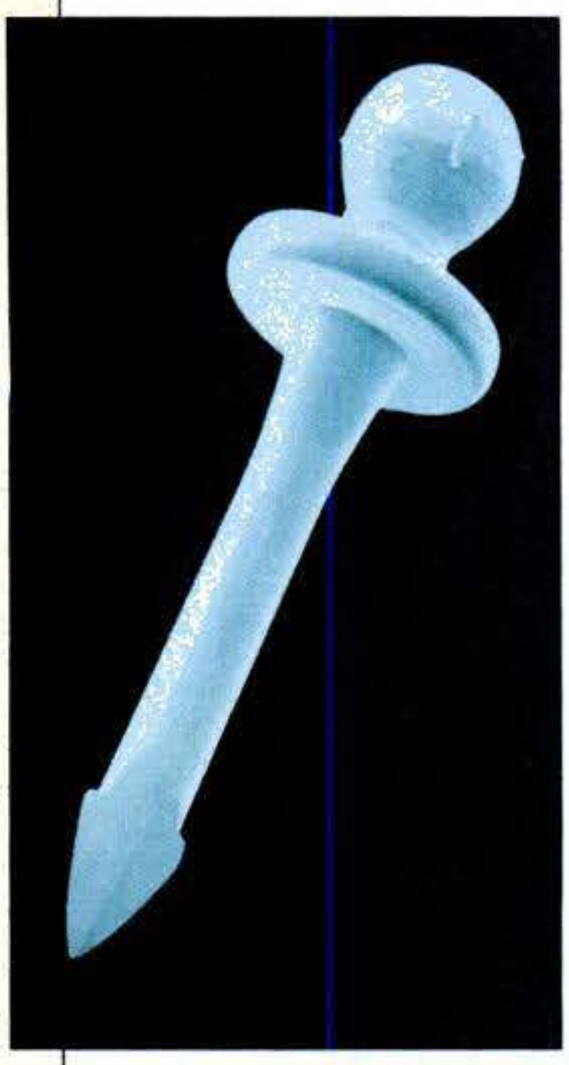
THE INSTRUMENTS OF SIGHT



This tack, 2.5 mm long, clips detached retinas back in place.

The artificial retina project depends on internal eye surgery. In the late 1960s, Dr. Robert Machemer, later to become head of the Duke University Eye Center in Durham, N.C., invented vitreous surgery: operating on the gelatinous body that fills most of the eye. During the past 20 years, internal eye surgery has exploded, largely through innovative tools.

Many of these tools are designed at the Biophysics Laboratory of the Duke University Eye Center. Dyson Hickingbotham, who runs the lab, says that he makes two or three new tools every month. The tools must fit through a one-millimeter tube inserted through the outside of the eye. Hickingbotham showed me a pair of tiny scissors with one-millimeter blades. Many of the devices, however, are multifunctional. One device has a fiber-optic light, provides suction and infusion of fluids, and can emit a radio frequency signal that seals any sources of bleeding.

Microelectronic Computer Center of North Carolina (MCNC) in Research Triangle Park is applying integrated circuit technology to surgical tools. "The technology that you use in mass-producing transistors on an integrated circuit," Dr. Richard Fair explains, "can also be used in mass-producing these tiny surgical blades, which right now are handmade and cost thousands of dollars apiece. We can mass-produce them for a fraction of that cost." Thus far, MCNC has made tiny blades for scissors, and they should be used in surgery soon.

The artificial retina project, however, depended most on the retinal tack: a nail-like part 2.5 millimeters long and as thick as a couple of human hairs. The tack was invented by Dr. Eugene de Juan and is used to clip a detached retina back in place. "This technology showed us that you can implant something on the surface of the retina," says Dr. Mark Humayun. And that's precisely what must be done to attach an artificial retina.—*M. M.*

sors might be used in them. De Juan thought the idea was intriguing. They soon came up with a plan to test the possibility of providing sight for blind people by surgically implanting an artificial retina.

Human photoreceptors are located at the back of the retina. What we see passes through most of the retina first. The information is then passed forward, toward the front of the retina through a network of cells, the last of which are the ganglion cells, a class of neurons in the retina. About one million ganglion cells lie just beneath the front of the retina; these cells pass through the optic nerve, which carries the visual signals to the brain. The investigators surmised that it might be possible to bypass the photoreceptors in the retina by electrically stimulating the ganglion cells. That's just what the team did in the experiments with Churchie and Dillis. The probe provided current to ganglion cells, which carried a signal to the brain, and the patients "saw" light.

At the beginning, however, the investigators had to resolve several questions before they could test their ideas on human patients. No one knew if light-sensitive cells on a chip could be designed to pass information to the ganglion cells. How do you make this occur? Humayun and Propst first set out to find an answer through experiments in animal vision.

With tools in hand, Humayun and Propst began. They wondered if an electrical shock could "turn on" the retina just as light switches it on in sighted animals. To find out, they fitted sighted rabbits with contact-lens electrodes—essentially a lens that can deliver an electric stimulus into the eye. But even if a rabbit "saw" something, it couldn't say so. Therefore, the investigators also recorded the electrical activity in the rabbit's visual cortex, the part of the brain that plays a primary role in vision. When Humayun and Propst sent a small signal through the contact lens, electrical activity soon appeared from the visual cortex, meaning that the electrical current had switched on the visual system. Humayun and Propst found the same response when they performed the experiments on rabbits that lacked functional photoreceptors, similar to humans suffering from retinitis pigmentosa.

But the ultimate goal of the artificial retina project was to place a device *inside* the human eye and stimulate specific points on the front of the retina. That meant the animal experiments would need to be performed inside the eye. Humayun and Propst fine-tuned their approach and, after a few years of work, they showed that extremely small electrical shocks to the front of the retina could pass information to the ganglion cells.

While Humayun and Propst demonstrated the project's biological feasibility, engineers brought into the project from North Carolina State University at Raleigh attacked the microelectronics of a light-sensitive chip. Their first question was: How much resolution should the device provide? If zero pixels (picture elements) equated to black, how many needed to be on the chip to provide an image?

The path from utter darkness to a world of light starts with one pixel, argues Phillips. "If you have zero pixels of resolution, that's total blindness," he explains. "The usefulness of an artificial retina increases rapidly with very small numbers. If I had just one pixel, and it was either light or dark, I would have enormously more information than a blind person's got. I'd have some orientational information." Imagining that he had only one pixel's worth of information, Phillips looks around the room. "That must be the window," he says as he turns one way. "That must not be the window," he continues as he faces a dark wall. "If you have four pixels, now it gets really interesting." As it turns out, four pixels are enough to sense light and dark, and even motion and orientation. But more complex problems require more pixels. It takes about 64 pixels to identify letters and about 256 pixels to read. To form a low-grade image, essentially fuzzy vision, you need about 1,024 pixels. But you don't need a million pixels to see, even though the retina has that many ganglion cells.

Fortunately, the team didn't have to create the light-sensitive chips from scratch. Researcher Ralph Cavin of North Carolina State contacted an old friend, Dr. Carver Mead of the California Institute of Technology in Pasadena. Mead had been making these very chips for some time. Nevertheless, Cavin says, "It seemed like a pretty tall hill for us to climb."

In late 1989, the group at North Carolina State approached Tom Gray, a graduate student. For a course project, he designed a 14-by-14-pixel array, modeled after Mead's work. Gray packed 196 pixels into a 2.2-millimeter-square area. "Basically, I wanted to see if the chip was sensitive to light," Gray explains. "So, I covered half of it and shined a light on it to see if the dark side was dark and the light side was light. It worked."

Cavin says that a light-sensitive

[Continued on page 76]

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SCIENCE CITÉ

How a political debacle gave rise to the world's largest science center.

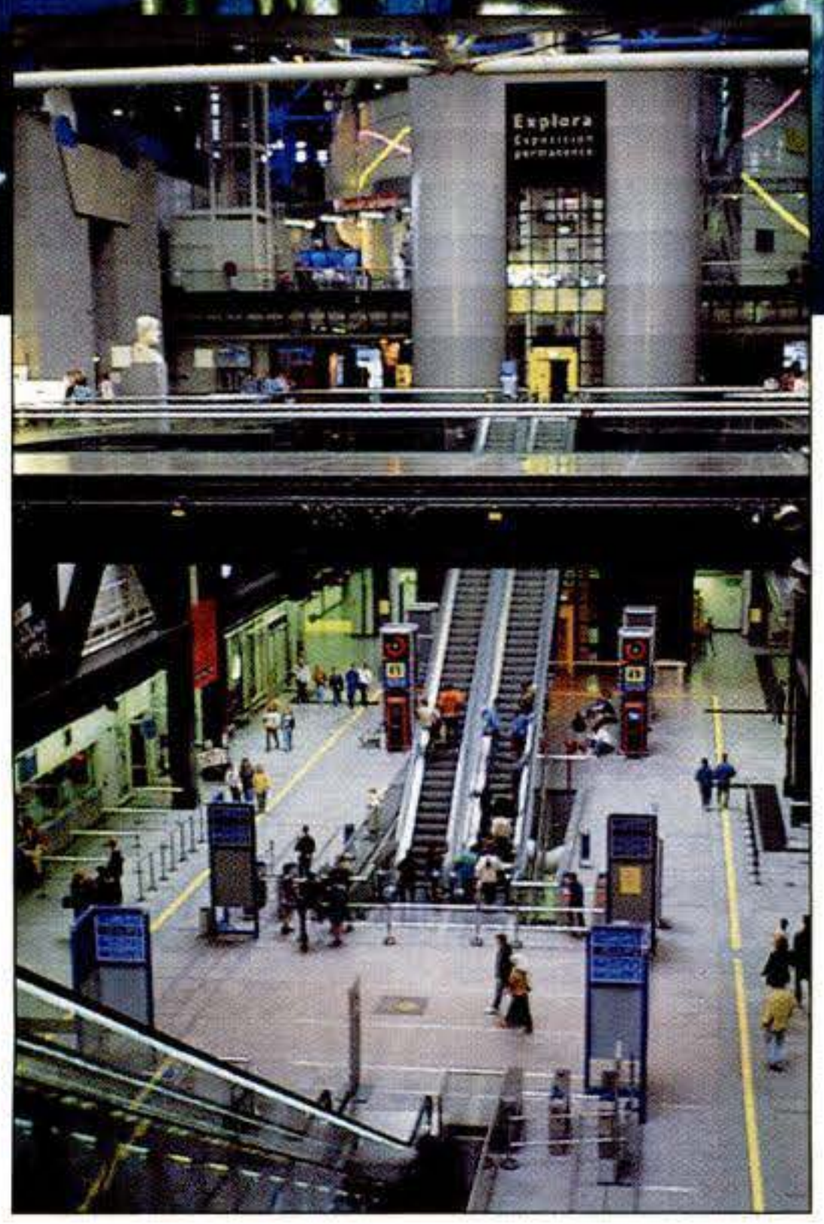
BY ARTHUR FISHER

PHOTOGRAPHS BY THE AUTHOR

You can't really call it a museum, at least not by conventional standards. Unlike the Smithsonian Institution in Washington, D.C., or the American Museum of Natural History in New York, for example, it has no collections—no priceless gems, no antique instruments, no dinosaurs, no meteorites.

What is it, then? "A giant machine for communicating and popularizing science and technology," says Joël de Rosnay, director of development and international relations for Paris's la Cité des Sciences et de l'Industrie—the city of science and technology. "We cover all disciplines, create major exhibits on themes that are of interest to the public. We have links to industry and work

PIERRE CARRERE



Once destined to be Europe's largest meat market, the enormous building at left in this photo taken at dusk (top) houses the main part of Paris's famed la Cité des Sciences et de l'Industrie. Facing it across a moat is the spherical Géode, France's first Omnimax theater, with the world's largest movie screen (seen also on the preceding page).

Inside the vast main hall of the Cité are more than 430,000 square feet of exhibits, ranging through three levels connected by escalators and elevators. Libraries and other facilities occupy two subterranean levels.

with the media. We have classes of students coming here for extended periods. We have a tremendous library . . . but no collections. That's why we are not technically a museum."

Museum or no, the Cité is certainly big, as its name suggests. In sheer size, it is unrivaled. The main building, an architectural wonder sheathed in glass, is enormous—longer than one-and-a-half football fields and taller, at 57 meters, than Paris's Arc de Triomphe. Its volume is enough to swallow three entire Pompidou Centers, another of Paris's stellar attractions.

It has more than 400,000 square feet of exhibition space on five levels, encompassing: a 7.5-acre permanent exhibit called Explora, with its four key concepts—the universe, life, matter, and communication; annual exhibits on different themes; a new, permanent exhibit on the environment; a children's section, the Cité des Enfants, the largest interactive exhibition center of its kind in Europe; and a multimedia library with more than 300,000 books, 500 periodicals (including POPULAR SCIENCE), and 3,000 audiovisual documents. Many of the exhibits are accessible to non-French speakers.

That's not all. The Cité also has: a news center where journalists can glean the latest developments in science and technology; an international conference center, the Palais des Congrès, that is host to major scientific and industrial meetings; a planetarium holding 250 swiveling and reclining seats that is equipped with 140 projectors and a Starball system that can display the motions of 10,000 stars; three theaters; a bank; an aquarium; a bookstore; a gift shop; and three restaurants.

Facing this building and reflecting it in its polished steel exterior is France's first Omnimax theater, the Géode, a sphere 36 meters in diameter with the world's largest movie screen.

A separate building houses the Cinaxe, Europe's first "dynamic" movie theater. This is actually a giant simulator inside which 60 people can experience spaceflight, a bobsled run, a plummeting helicopter trip, or other similarly disorienting, gut-wrenching excursions for four or five minutes. The simulator cabin is mounted on hydraulic pistons that can tip it in any direction at an angle of up to 30 degrees.

One can even visit a full-scale submarine, the *Argonaute*. Headsets deliver a multilingual commentary on the sub's various stations: the crew station, the central operations station, and the forward torpedo-launching station.

The Cité resides in a 136-acre park, the Parc de la Villette in the northeast corner of Paris, about 20 minutes from the center; it is the largest green space

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within the city limits (la Villette is, literally, "little town") and eventually will also contain a multi-structure cultural attraction devoted to music.

The strangest aspect of this tremendously successful science center, which attracts more than five million visitors a year (rivaling the Louvre and the Eiffel tower) is that it sprang from a major political and financial scandal.

The story is a curious one. The Parc de la Villette is an ideal place for a major market because it is threaded by two important waterways: one running south to the Seine and north to the countryside, and the other running east and west. La Villette was once the site of an abbatoir: Animals were transported by barge and butchered there, with the meat then distributed throughout Paris and the surrounding area. A visitor to la Cité with a vivid imagination might today think to hear the lowing of kine and the squealing of swine.

In the 1960s, the national government devised a grandiose scheme to build Europe's largest meat-processing plant at la Villette. Besides facilities for slaughtering the animals, a huge hall would serve as a great meat market. Construction began, but was plagued by cost overruns as enormous as the building. To make matters worse, the original concept became obsolete and had to be abandoned by the end of the decade. New technology in meat cutting and trimming, air-conditioning, and the like made it possible to decentralize the meat-packing industry instead of concentrating it in one place. These developments made it profitable to butcher animals and sell the meat locally.

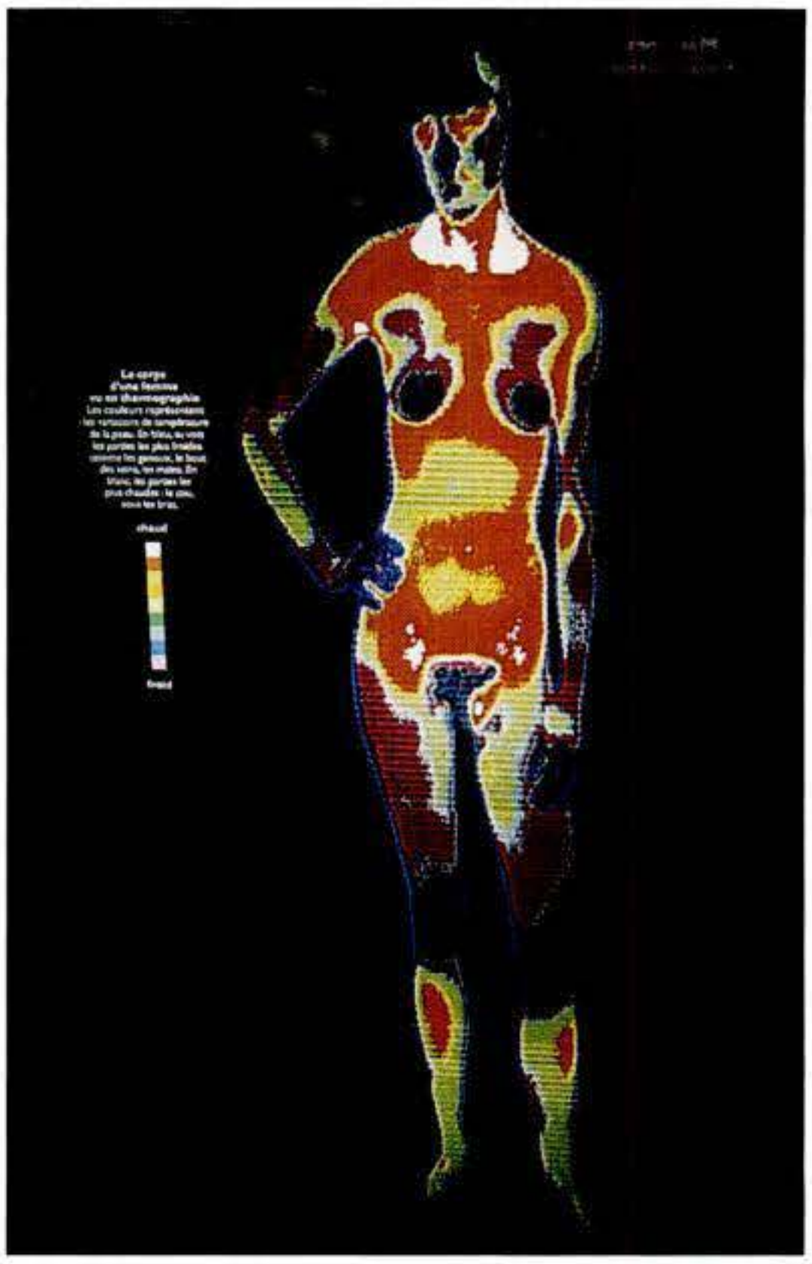
It was an economic fiasco and a major political scandal, according to de Rosnay. "The government was left with this big piece of real estate and an enormous building that was only partially finished."

What to do with this white elephant?

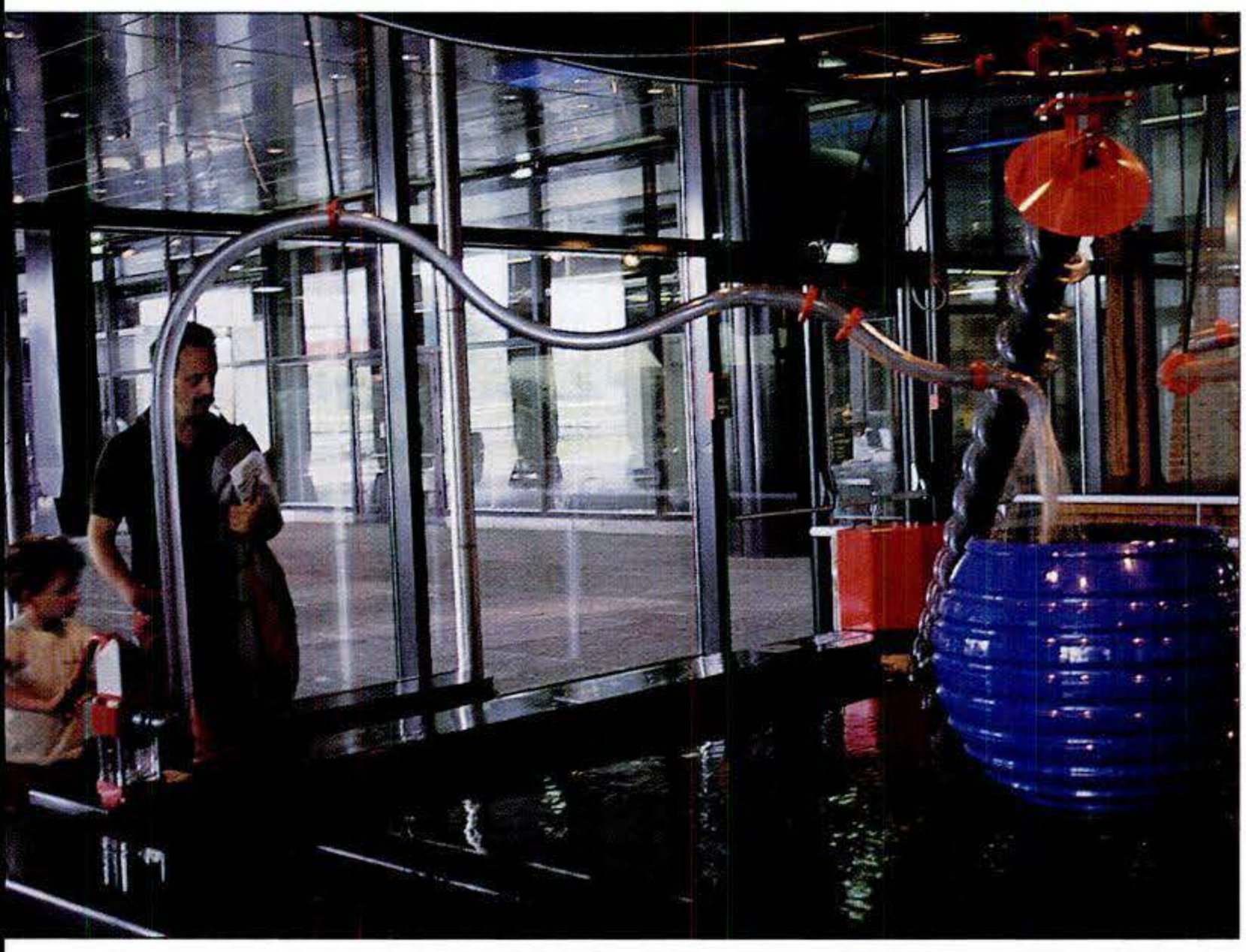
As de Rosnay tells it, the government was advised to convert the plant to a museum of industry; the concept was then changed to a museum of science and industry.

In 1978, then-President Valéry Giscard d'Estaing asked Maurice Lévy, an eminent physicist and the former head of the National Center for Space Studies, to form a small team to study the plan. De Rosnay became part of that team. "Lévy and the team," he says, "made a proposal that clearly outlined many of the things that we do now. Lévy stressed from the beginning that the word 'museum' was inadequate to denote all the manifold functions and attractions of the Cité. Besides, in France at least, the word smacks of the musty past, and we are aimed toward the future."

The go-ahead for the project was given by President François Mitterand in 1981, and the noted architect Adrien Fainsilber was assigned the daunting task of rescuing the abandoned meat market. He succeeded brilliantly, turning the otherwise useless and cavernous central space that had been intended to serve as a meat sales hall into a



Tennis, anyone? This near-life-size thermogram of a woman and her tennis racket displays the uneven heat output of the human body, often a useful means of detecting disease and other abnormal conditions.



Children can learn about all manner of water-moving devices—from simple pumps to Archimedes' screw—at this interactive hydraulic exhibit. The aim is to get water into the tipping barrel at the middle of the pool.

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A visiting grandfather and grandchild try their hand-eye skills by using a robot manipulator arm to build and disassemble structures with architectural blocks. The Cité has more interactive exhibits than any other science center in the world.

stunning, cathedral-like "nave." The 330-foot-long, 165-foot-tall space is served by escalators and elevators that lead to three levels of exhibits and two subterranean floors.

On Feb. 17, 1985, an official decree established the Cité under the aegis of the Ministries of Research and Industry, with the cultural mission of "making accessible to the public the development of the sciences, technology, and industrial expertise." It is part of the French government's master plan for the development of modern Paris, a plan that also includes the Louvre, the Arc de la Défense, the Musée d'Orsay, and the Opéra de la Bastille. The Cité opened in 1986; de Rosnay, formerly director of the famed Institut Pasteur in Paris, joined full-time in 1987.

The theme of the Cité in 1992, when I visited, was Man and Health, with an especially fascinating section on disease that included an examination of the most recent outbreak of plague, in the 18th century. The 1993 theme is Man and the City; for 1994 it will be Man and Materials.

Part of the Cité's activity during a theme year is to publish and distribute books, cassettes, kits, and other materials. Each theme has to be planned three years in advance.

Like the permanent Explora, these annual exhibits make heavy use of interactive and multimedia techniques. De Rosnay is not entirely satisfied with their effectiveness, however. "The Cité is both a communications machine and an expert system—

HANDS ACROSS THE SEA

La Cité des Sciences et de l'Industrie maintains close cultural contact with a number of other science centers worldwide—and none closer than with San Francisco's Exploratorium. In fact, the present director of the Exploratorium, Goéry Delacôte, was a member of the planning team that was instrumental in setting the Cité's mission. Delacôte joined the Exploratorium in 1991 from a position as a director of the French National Research Center.

In 1986, the Cité commissioned a major exhibition, which opened in May 1987, called "Seeing the Light with the Exploratorium." It replicated 76 of the more than 600 Exploratorium exhibits. All the replications were based on the theme of light. The exhibition is now permanent at the Cité and is called "Jeu de Lumière," or "play of light."

The dazzling exhibits explore such phenomena as reflection and refraction, color, shadows, light mixing, depth-perception, illusions, and the nature of vision. Here are some of them:

•Everyone is You and Me—Two visitors sit facing one another on each side of a half-silvered mirror. By shifting position slightly, one can gradually superimpose his face on the other's, with startling and rewarding results.

•Duck into Kaleidoscope—One person becomes a crowd when mirrors joined at 60-degree angles bounce an image back and forth to produce a host of reflections.

•Mirrorly a Window—Hand-eye *un*coordination occurs, to an unsettling degree, when a visitor puts both hands on the exhibit and looks into a mirror from the side.

•Distorted Room—The same person can appear as either a midget or a giant, depending on what part of this "fun-house" room he stands in.—*A. F.*

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hardware and software. We need to improve the user-friendliness of the hardware in this big building, a constant enterprise. We'll be happy when it's as friendly as a Macintosh. For the future, we are launching an internal forecasting program that will help us answer such questions as: What is the future of interactive technology? Should we be more high tech or high touch?"

Typically, the choices in interactive exhibits have been either high tech/low touch (low touch requires little human intervention or assistance) or low tech/high touch. "I believe we should be more high touch," de Rosnay says.

An example of high tech/low touch, de Rosnay explains, is a stand-alone exhibit featuring push buttons, a tactile screen, and multimedia. "When the visitor approaches, the machine starts talking, or else he pushes a button and the exhibit goes into operation. There are no museum people around—that's low touch.

"The opposite approach, low tech/high touch, is typical of some science centers in the United States, especially in parts of San Francisco's Exploratorium, with very simple exhibits based on, for example, a pendulum or a wheel. Two or three museum people are usually standing nearby, and the visitor can ask questions and have things explained." (For the close connection between interactive exhibits at the Cité des Sciences and the Exploratorium, see Hands Across the Sea.)

Some approaches can fall in between those two extremes, de Rosnay says. For example, a center might use videodiscs, computers, and other high-tech equipment, but augment them with special "animators," guides who are very well informed and can help people find their way through a "knowledge maze."

At the Cité, another significant shortcut through knowledge mazes is via multimedia libraries, called "médiatheques" as a twist on "bibliotheques."

"We are geared to explain science and technology," says François Reiner, director of the médiatheques, which serve a million visitors a year. These libraries gather up documents of all kinds—printed materials, audiovisual, and software, including CD-ROMs and interactive videodiscs—and make them accessible and attractive to the Cité's visitors. In addition to visitors to the museum, the médiatheques also draw students and others who come to the Cité principally to use the médiatheques.

Originally, Reiner says, the médiatheques' architects wanted to separate different kinds of users physically: adults from children, for example. "But we wanted children to be able to use the whole library if they wanted. For instance, there is no reason a child of ten who is interested in airplanes shouldn't be able to use *Jane's All the World's Aircraft*, even

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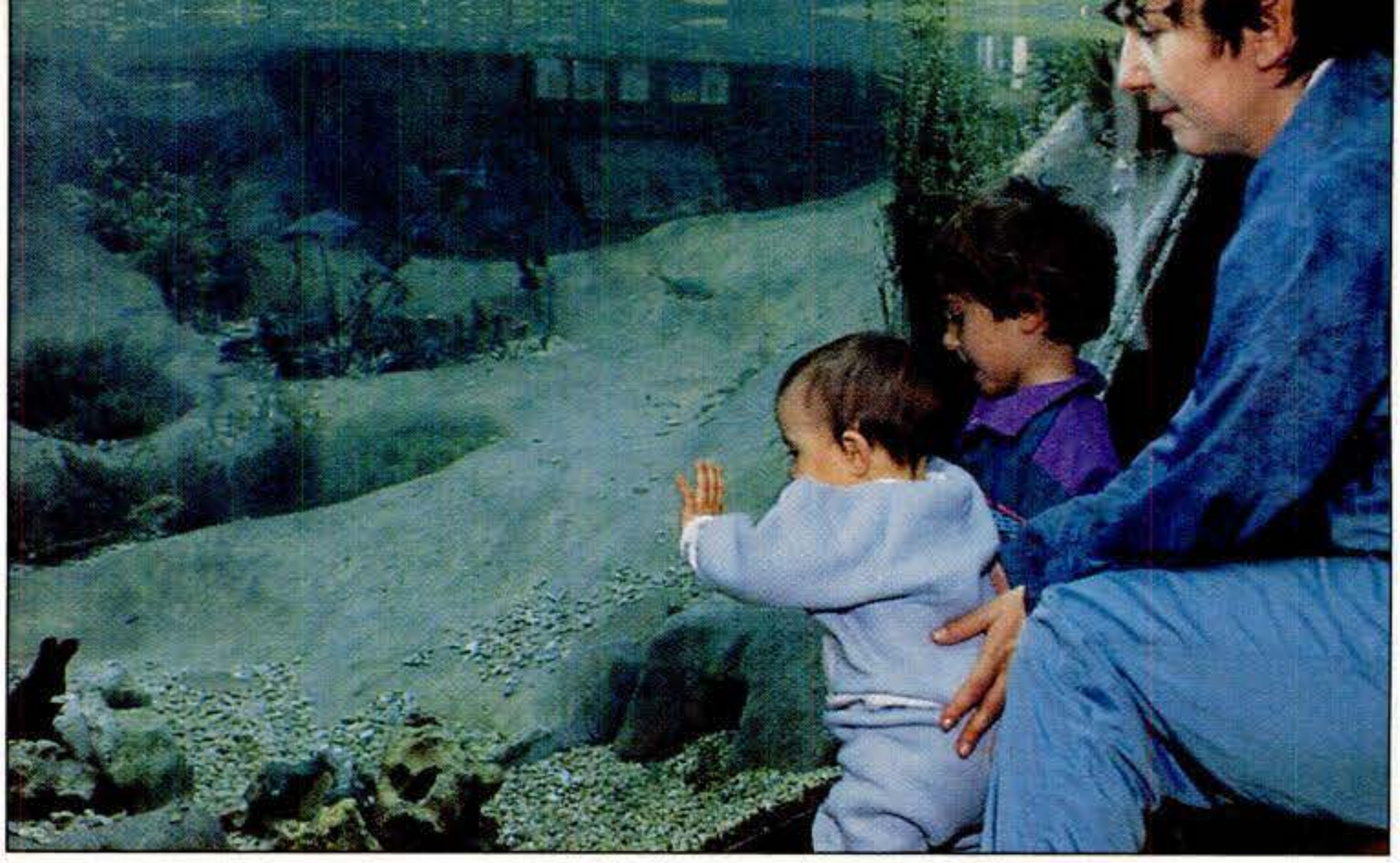
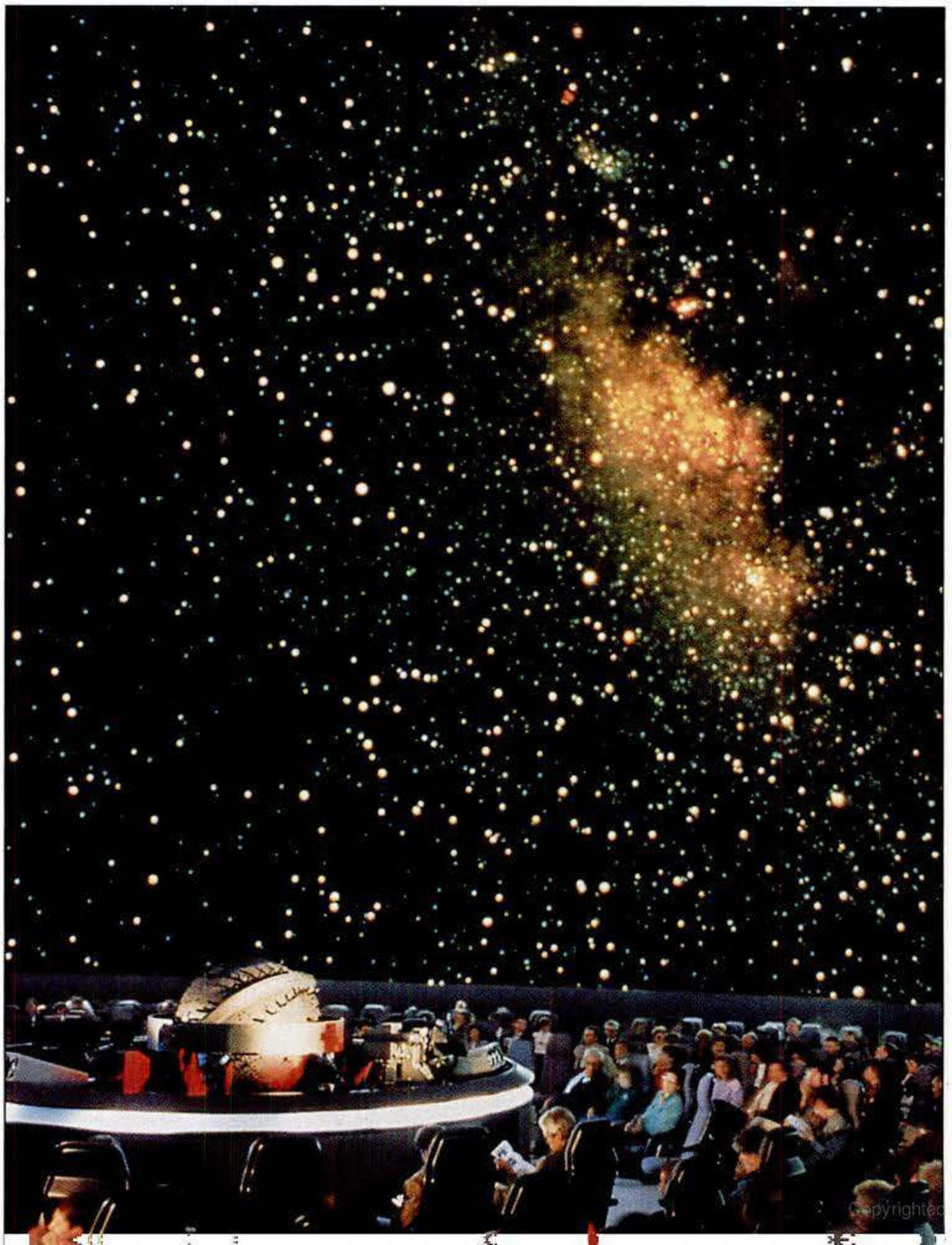


PIERRE CARRERE

The Cité's "Science Village" for children (the Cité des Enfants) welcomes all from 3 to 12 years old. Here a toddler and his brother explore the wonders of an underwater environment.



P. PRIEUR

One of three theaters, the Cité's planetarium has an ultrasophisticated projection system that can track the motions of 10,000 stars.

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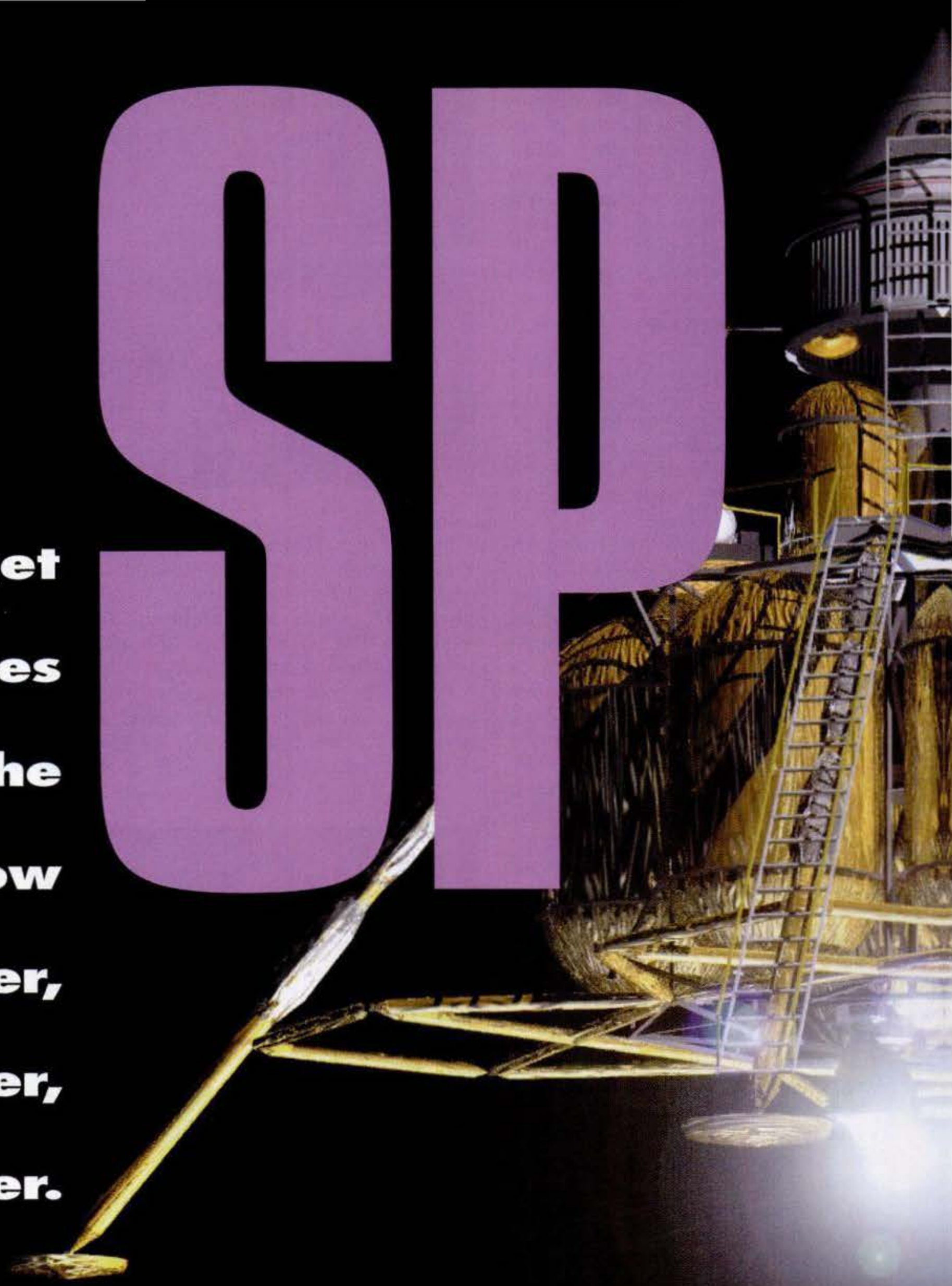
SP

Forget about tunes of glory. The melody now is smaller, faster, cheaper.



BY STUART F. BROWN

America's space program was once a source of pride and inspiration to the nation. Now it is a shambles, its mission unclear, its very existence at hazard.

It is reeling under the impact of three recent developments: One, the sensational collapse of the Soviet Union. Second, the arrival, after 12 years, of a new Democratic administration with its own as yet undefined space and technology policy agenda. And third, the softening of the economy, a worldwide phenomenon. These treble tremors are drastically changing the complexion of the space activities that could unfold in the next decade and beyond.

GE AFTER THE RACE

This turbulent time is in stark contrast to the glory days of the Space Age. It was to reinforce the pride of country as well as to reaffirm this nation's dominance as a world power that President John F. Kennedy trumpeted a visionary plan to land Americans on the moon. And the country responded to that vision, basking in the reflected glory of the space program's achievements.

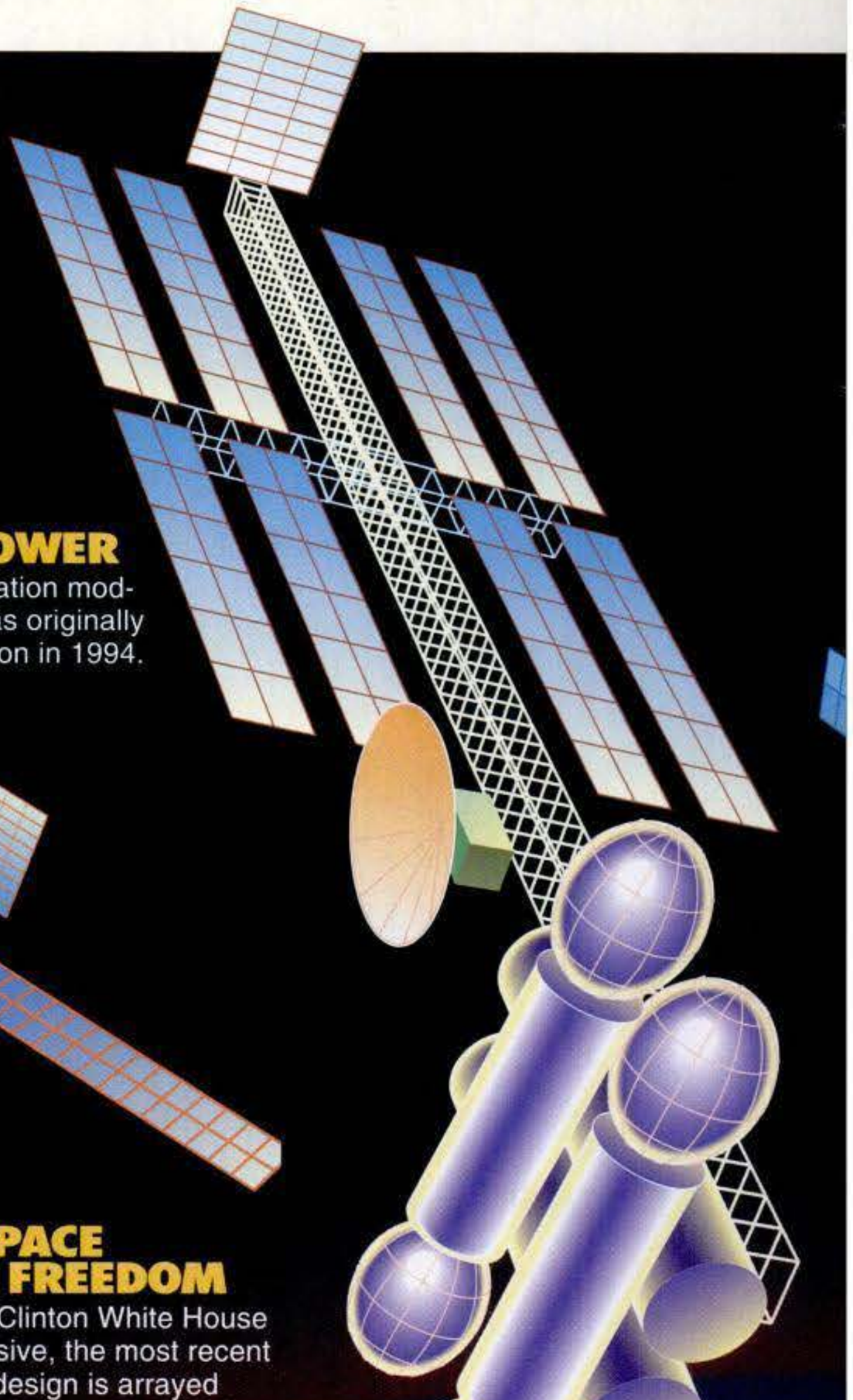
On July 20, 1969, only 11 years after NASA's formation, American astronauts landed at Tranquility Base on the moon. During the next three years, 12 Apollo astronauts roamed the lunar surface. In 1976, the Viking Lander probed for life on Mars. Daring unmanned trips to yet other planets yielded a thousandfold

In this computer-generated NASA scenario, a new generation of landing craft fires retrorockets while descending to the lunar surface to establish a manned outpost. Money to pay for such a mission appears unlikely to materialize anytime soon.

FRASSANITO & ASSOCIATES

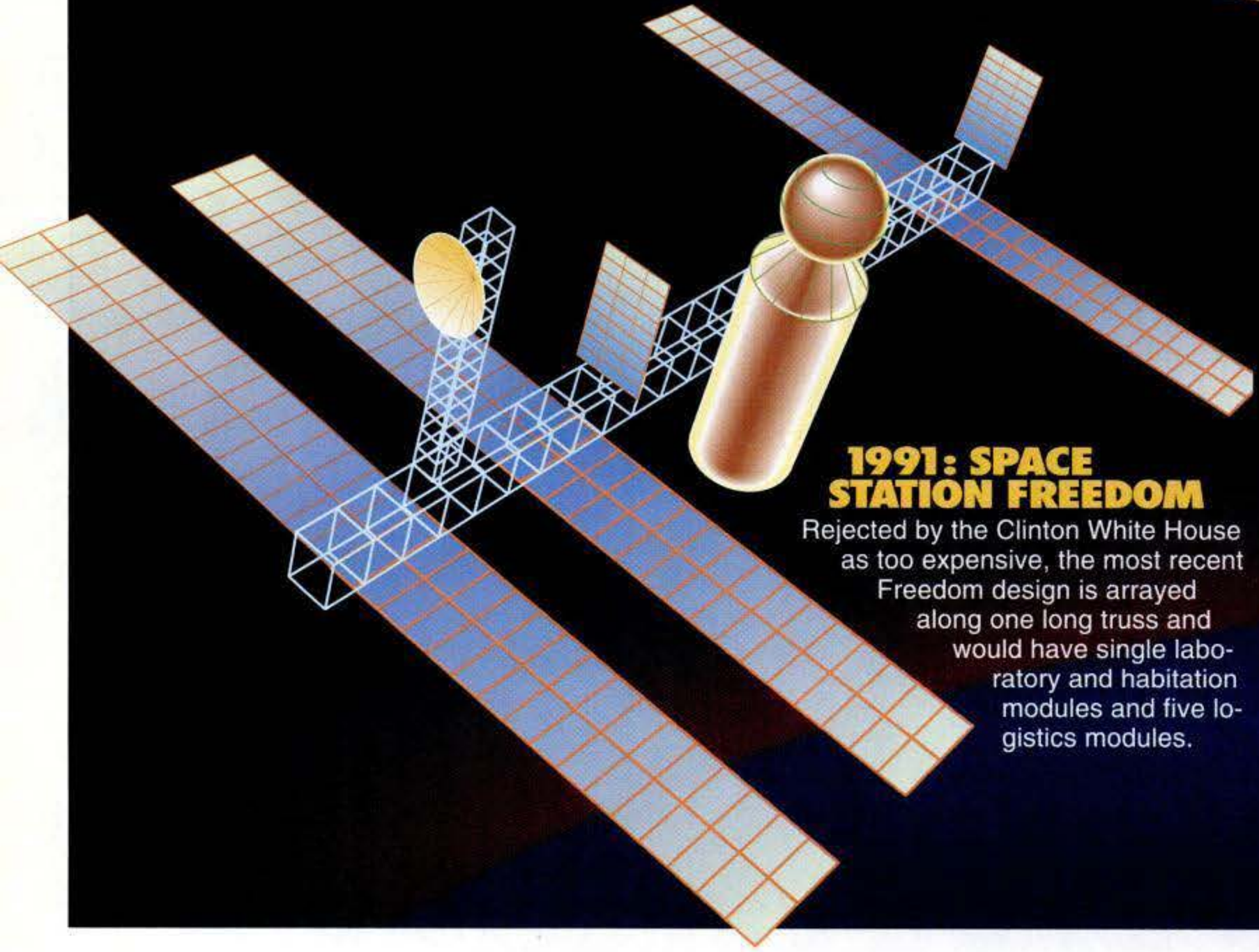
NASA'S PAPER SPACE STATION: A PERPETUAL DESIGN EXERCISE?

Since 1985, at least 11 space station designs of varying size and cost have been proposed, including the two shown below. On the page at right are four that have been recently considered, one of them Russian in origin. Those labeled options A,B, and C are similar to the three designs submitted in June to a White House advisory committee by a NASA redesign team. None of these meet the budget goals of $5 billion, $7 billion, or $9 billion set by the president's science advisor, John Gibbons.



1986: THE POWER TOWER

A design incorporating pairs of laboratory and habitation modules and a single pressurized logistics module, it was originally scheduled for permanently manned operation in 1994.



1991: SPACE STATION FREEDOM

Rejected by the Clinton White House as too expensive, the most recent Freedom design is arrayed along one long truss and would have single laboratory and habitation modules and five logistics modules.

increase in our knowledge of the solar system.

Behind the scenes, however, top level indecision, bureaucratic infighting, cost overruns, and congressional waffling were beginning to tarnish the space program's allure and blur its mission. The ending of the Apollo program and the trashing of the massive Saturn rockets disillusioned many. Then came the painful evolution of the space shuttle—with its enormous costs, delays, and an apparently avoidable *Challenger* disaster—and a string of other major technical failures, such as the recent Hubble Space Telescope fiasco. All contributed to a growing public disenchantment with the space hierarchy and its work.

Outside historical events are also inexorably molding the future of the space effort. With the Soviet Union a memory, the atmosphere of hostility and competition that bred the rationale for treating space as a race has evaporated. Now, Russia is clamoring for participation in the space projects of NASA and its international partners. It is dangling for sale a broad range of hardware and technical expertise developed in its own highly successful space program (see A Gallery of Russian Space Hardware).

On the domestic scene, the new administration brings with it new priorities; the glory and adventure of space exploration are not high among them. The Clinton team wants to use the space program to develop new technologies with earthbound uses. This is bad tidings for manned missions to the moon and Mars, and the crash programs for building new launchers to get them there; they have now been indefinitely postponed. The new focus will be on cheaper robot probes that can be built in less time and quickly launched on space-science, planetary-exploration, and environmental-monitoring missions.

Tight money means that times are tough all over in the space business. Global recession is making it hard for governments to pump large amounts of money into civil space activities, which currently consume a worldwide total of about $25 billion per year.

If the United States is no longer to engage in bold (and expensive) space-faring, neither is any other nation likely to eclipse American ef-

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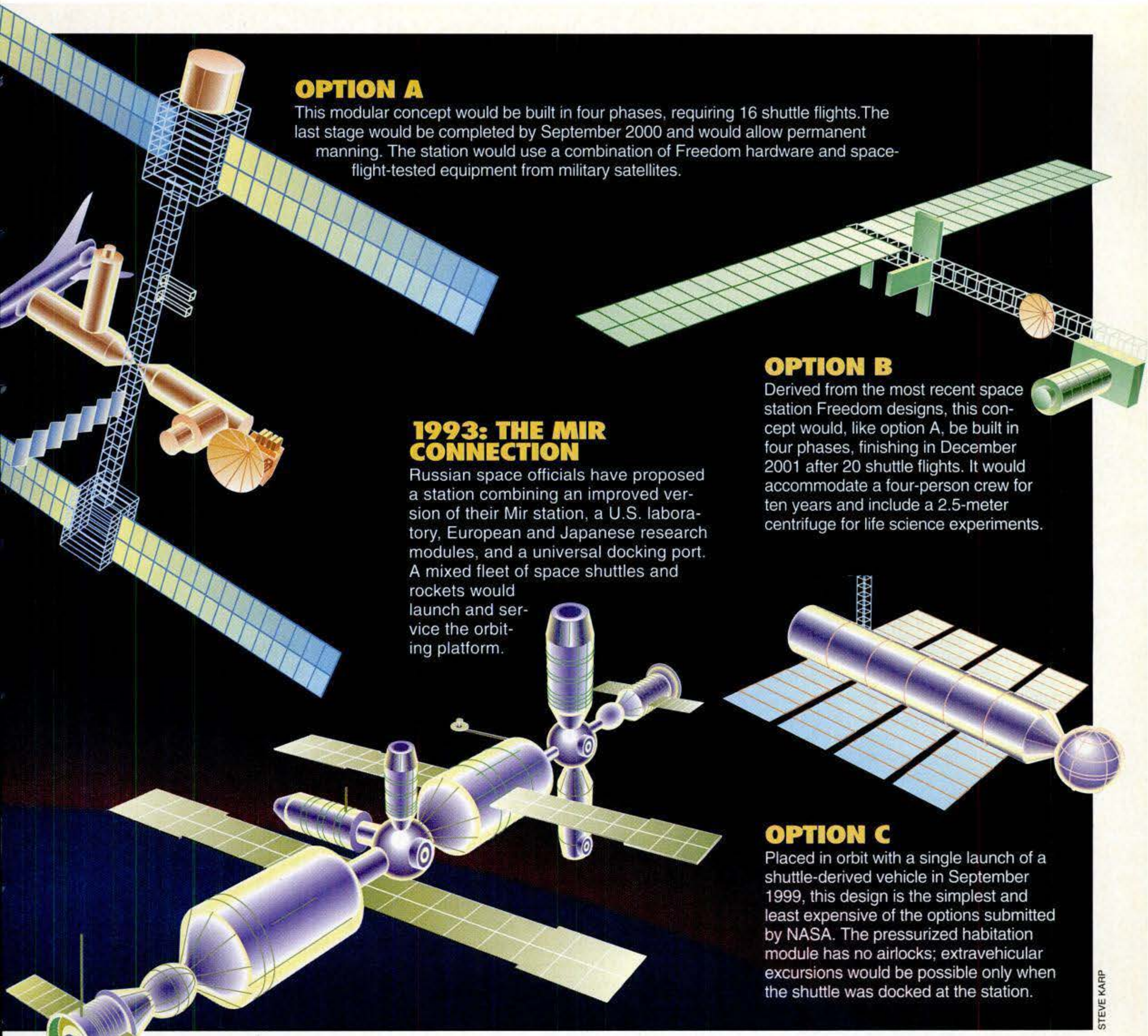
OPTION A
This modular concept would be built in four phases, requiring 16 shuttle flights. The last stage would be completed by September 2000 and would allow permanent manning. The station would use a combination of Freedom hardware and space-flight-tested equipment from military satellites.
OPTION B
Derived from the most recent space station Freedom designs, this concept would, like option A, be built in four phases, finishing in December 2001 after 20 shuttle flights. It would accommodate a four-person crew for ten years and include a 2.5-meter centrifuge for life science experiments.
1993: THE MIR CONNECTION
Russian space officials have proposed a station combining an improved version of their Mir station, a U.S. laboratory, European and Japanese research modules, and a universal docking port. A mixed fleet of space shuttles and rockets would launch and service the orbiting platform.
OPTION C
Placed in orbit with a single launch of a shuttle-derived vehicle in September 1999, this design is the simplest and least expensive of the options submitted by NASA. The pressurized habitation module has no airlocks; extravehicular excursions would be possible only when the shuttle was docked at the station.
STEVE KARP

forts. Russia is hard-pressed to launch any space vehicles. The 13 member nations of the European Space Agency (ESA) are facing political and budgetary woes that have forced them to back away from the original goal of becoming a full-fledged competitor to the United States and the Soviet Union, capable of a range of independent space activities. ESA has recently canceled an astronaut-tended orbiting laboratory and its Hermes space plane, a craft planned to ferry a three-person crew and some cargo into orbit, and has scaled back many other projects. Only ESA's Ariane launcher program and its space-science activities have escaped major cutbacks.

Officials from 70 nations who attended the World Space Congress, a major international conference held in Washington a year ago, began talking about the need for multinational cost-sharing and cooperation. Although no blueprint for it exists, a few optimists have proposed the idea of eventually forming a joint American, European, and Russian space program.

NASA has learned that it must get accustomed to living on about one-third less money than agency planners once thought they could count on. From 1983 to 1992, the annual NASA budget grew from $7 billion to $14 billion, as declining military hardware spending inspired Congress to shift a "peace dividend" into the space program. Anticipating continued congressional largess, the agency assumed its budget would increase to as much as $25 billion by 1995. Costly projects seemed affordable.

The days of generous raises are now history. The prolonged recession and pressure on Congress to attend to social needs means that NASA must make do with about $15 billion annually in inflation-adjusted dollars for the next few years. As a result, doing things less expensively has become the only way to keep a reasonable mix of activities alive.

Piloting the space agency through the shoals of change is the task assigned to Daniel Goldin, who was brought in as NASA chief administrator a year and a half ago after the Bush White House fired Adm. Richard Truly, the former astronaut who had been administrator since 1989. Truly was felt to have moved too slowly in weaning NASA from its reliance on the costly space shuttle

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THE MILITARY IN SPACE

A key development in the military space arena is the repackaging of the Strategic Defense Initiative (SDI) program, or Star Wars, as the Ballistic Missile Defense Organization (BMDO). Defense secretary Les Aspin shifted the program's focus away from space-based destruction of intercontinental nuclear missiles to ground-based interception of tactical missiles, such as the Scuds used by Iraq in the Persian Gulf war. The BMDO is still handsomely funded, with a $3.8 billion budget for fiscal year 1993. SDI research projects consumed a total of nearly $30 billion since the program was established by Ronald Reagan.

The world's military is believed to spend about $25 billion per year on space activities, the same amount civil space programs receive. In the United States, however, spending on military space activities began to surpass the level of civil space funding in 1981. Military spacecraft are typically used for reconnaissance, communications, navigation, weather reporting, and early warning of missile attack.

An estimated $6 billion per year has been spent by the Defense Department's National Reconnaissance Office (NRO), an agency that operates the country's network of sophisticated spy satellites under direction from the CIA. Last year, the Pentagon officially owned up to the NRO's secret existence and name—both of which had been known for some time to observers of the space intelligence sector. And in spite of its grave economic and political woes, former arch-enemy Russia has managed to continue launching military communications and reconnaissance satellites.

A welcome peace dividend for earth scientists is now coming out of the fabulously expensive space reconnaissance world. Prodded last year by Sen. Sam Nunn and then-Sen. Albert Gore, the Defense Department and the CIA began combing through tons of satellite photos taken over many years to determine which could be useful to scientists studying global climate changes. Meaningful details, such as quantity of snowfall, the extent of vegetation cover, and other variables may be contained in the formerly classified images.

Anyone who watched NASA space science craft being bumped off the space shuttle in favor of "classified defense payloads" during the 1980s might have concluded that the military was quietly taking over the civil space program. Was NASA just a front for the Pentagon?

Actually, the military had come to dread the space shuttle, with its infrequent flights and the three-year launch hiatus caused by the *Challenger* disaster. As soon as it could, the Air Force began designing spy satellites and other large military spacecraft that would fit on unmanned rockets such as the Titan IV. The Pentagon now has plans to launch more than 200 payloads on expendable rockets of various sizes in the next 13 years.

—*S. F. B.*

and embracing the now-postponed goal of sending people to Mars.

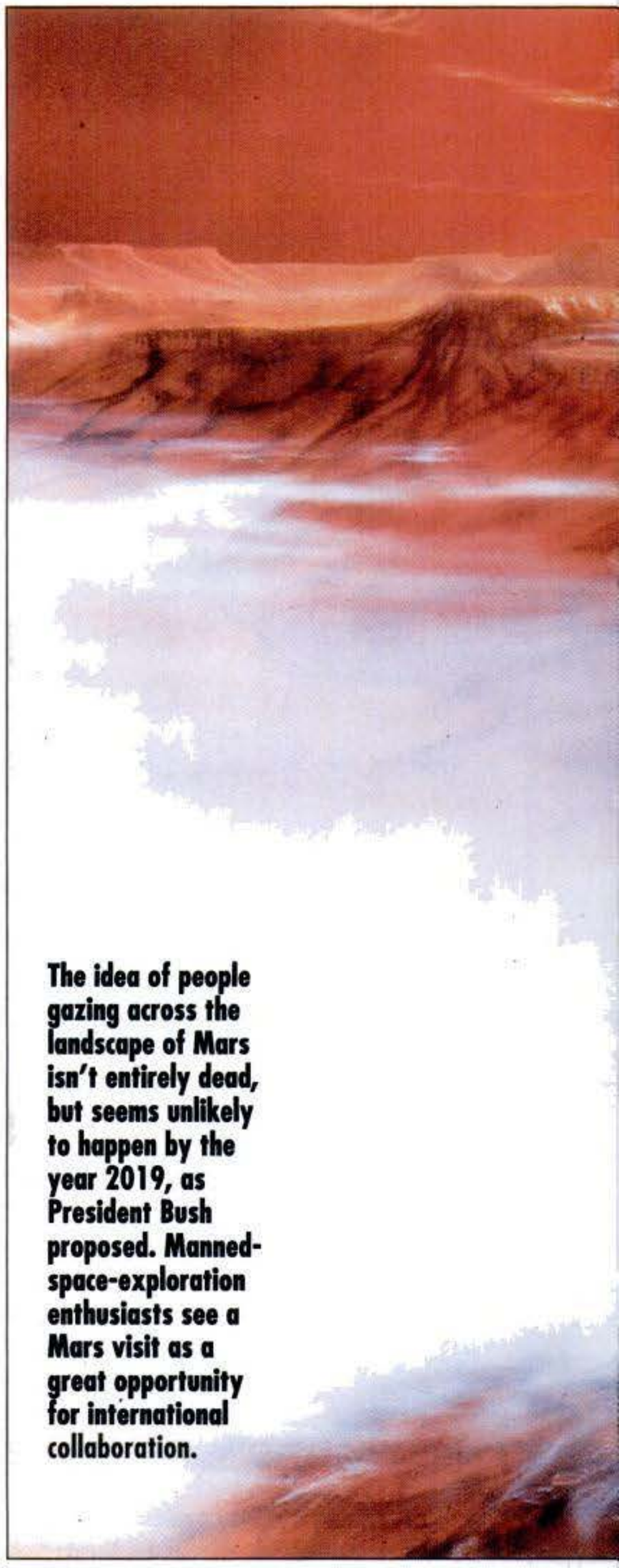
Goldin has shuffled the agency's top management and launched its 24,000 employees on a process of internal review and goal-setting intended to shake out bureaucratic cobwebs that collected during the two decades since the Apollo moon-landing program. The resulting tussles within NASA, and with congressional representatives and corporate lobbyists defending the status quo, have been fierce and have earned him many enemies, according to NASA sources who ask to remain anonymous.

A career aerospace engineer, Goldin came to NASA from the Space Technology Group of TRW Corp., where he managed a series of civilian and military spacecraft programs. He is a scrappy reformer who seems to have been everywhere at once since his appointment, pitching a creed of efficiency and relevance for the space program. Accomplishing more in less time without busting budgets is the new official religion at NASA, where the refrain "smaller, faster, cheaper" has been broadcast throughout the agency. The idea is to get away from building large, elaborate spacecraft, such as the original design for the planned Saturn-orbiting Cassini probe. Cassini's $4 billion price tag rivaled the expense of a manned mission.

"The antithesis of this is to build small to medium-size spacecraft that you can launch three years after the start of the program," Goldin said in an interview. "Let's say I launch ten satellites in a year. I can afford to lose two of them. It becomes OK to take risks. Now I begin coming to the technological cutting edge. The reason that the nation goes to the cutting edge is not just for inspiration, but for opportunity to bring back technology that can create new jobs. NASA must perform as an intentional engine for the creation of things that you can use."

Such talk is music to the ears of many space scientists. "I'm very high on what Goldin's doing. He's what NASA needs," says Dr. Bruce Murray, a California Institute of Technology planetary geologist who has long criticized the agency's ways ["Is the U.S. Lost in Space?" July '89]. "We need cheaper and quicker in both unmanned and manned spaceflight. The challenge now for NASA is that the direction they're going costs too much."

Buffeted by constant design changes and budgetary demands, the Freedom space station mirrors, more than any other program, the increasing turmoil in the space world.



The idea of people gazing across the landscape of Mars isn't entirely dead, but seems unlikely to happen by the year 2019, as President Bush proposed. Manned-space-exploration enthusiasts see a Mars visit as a great opportunity for international collaboration.

Freedom is supposed to be built by NASA together with ten European partners, Canada, and Japan. The White House has instructed NASA that spending for the orbiting laboratory over the next five years must be reduced to between $5 billion and $9 billion from the $14.6 billion the agency had originally requested. Try to share costs and hardware with the Russians, the administration ordered, while paring down the station from its planned configuration.

If the space station ends up being severely diminished or even canceled, NASA will emerge as an agency more closely focused on terrestrial concerns than it has been in the

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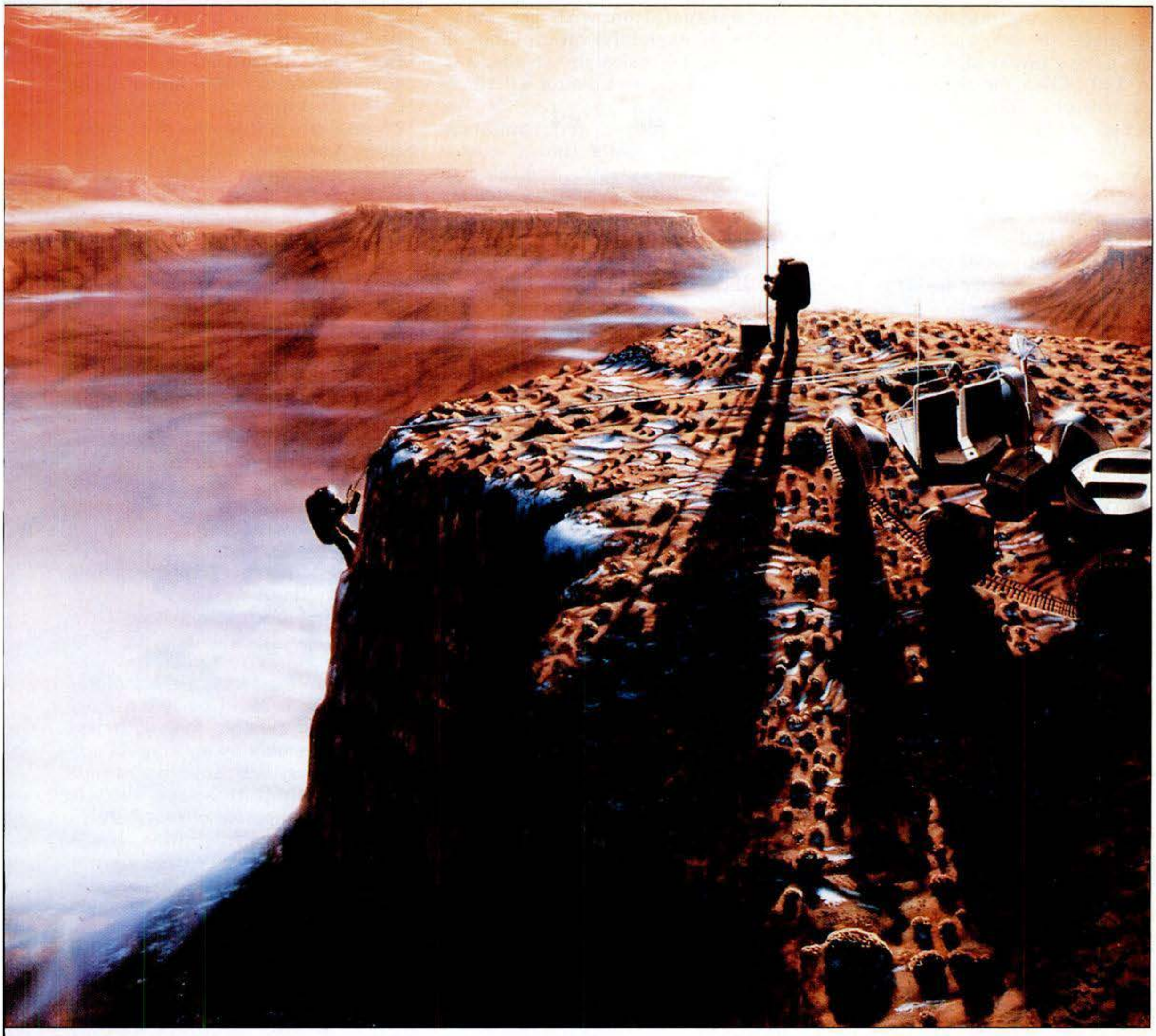

past. Within the belt-tightening order from the White House resides a message that NASA's activities will be judged in terms of their potential payoff in new industries and jobs, according to John M. Logsdon, director of the Space Policy Institute at George Washington University.

During the Reagan-Bush years, it was politically incorrect to speak openly of industrial policy, even though the government's longstanding support for defense and space represented the same thing by another name. Now, the new administration's belief in an overt and broader-ranging industrial policy could put NASA in competition with other activities for its financial sustenance. "The fundamental implication of the space station redesign is that Mr. Clinton is far less interested in spending money on space for its own sake than on technology that will have an impact on the economy," Logsdon says.

Indecision by policymakers and budgeteers over the international space station has made the beginning of the post-race Space Age seem like an out-of-focus movie with no discernible plot. Alternative space station proposals and sales pitches from Russian spacecraft builders have been in ample supply, along with uncertainties about whether the cheaper versions are feasible.

At the same time, a broad consensus has been lacking for exactly what the space station should accomplish in the first place. Goldin has at various times stated different primary roles for the orbiting platform. One is as a human-physiology lab for exploring serious health problems, such as permanent bone-mass loss, that are caused by long-duration weightlessness. Another is a materials-science facility for exploring new compounds and ultrapure crystals that cannot be produced on Earth. A third is as a gathering ground where international teams can learn how to collaborate in space.

But strong backing has failed to materialize for sending humans back to the moon and onward to Mars by 2019. That was the goal George Bush proclaimed but didn't bankroll in his 1989 Space Exploration Initiative. And that seriously weakens the human physiology justification for the space station. Without plans for imminent manned space ventures, it would mean spending huge amounts to pursue answers

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to non-pressing questions. By some estimates, Freedom's total price tag could have run as high as $30 billion to $40 billion for construction and launch, plus 30-year operating expenses of $100 billion or more.

Worse yet, promoting the station as a materials-processing laboratory has been pooh-poohed by a long list of prominent scientists, including James Van Allen and Bruce Murray, who see any possible gains as a trivial return on a huge investment. So what's the thing really for?

Still, NASA, its foreign partners, the White House, and Congress may end up hashing out a space station design and rationale that is acceptable to a majority of the participants, gets built, and actually begins orbiting Earth within a decade.

Russian space officials have lobbied vigorously for the consideration they're now receiving and have been backed by Russian President Boris Yeltsin, who reached an agreement with President Bill Clinton during their April summit meeting in Vancouver, B.C., to chart future space cooperation. Germany's research and technology minister has also encouraged joint space station efforts with Russia. Leading Russian scientist Roald Sagdeev, who is now based at the University of Maryland's East-West Space Science Center, is coordinating his country's participation in the effort.

Bringing the Russians into the conversation has added an internationalist appeal that is likely to fortify the shaky bipartisan congressional coalition that has so far kept the controversial Freedom project alive. But there is still a distinct possibility that lawmakers' mounting exasperation with the many years of expensive ground-bound space station research will result in the entire project being killed by Congress within the year.

One key player in formulating space policy, White House science adviser John Gibbons, indicated to reporters at a February science meeting that Ronald Reagan's fuzzy ideal of maintaining a permanent manned presence in space is a shaky justification for spending billions of dollars.

How did the space station come to be in this pickle? Space station Freedom is the offspring of a series of contractor projects in which $8 billion was spent since 1984 on endless paper studies and mock-up space station modules. Congress never became sufficiently convinced of the value of those plans to allocate enough money for a realistic construction and launch program. Thus, during successive redesigns the platform grew, then shrank again, in keeping with the fluctuating hopes for funding.

A chronic parallel problem, and a major contributor to Freedom's endangered status, has been NASA's lack of an unmanned heavy-lift rocket. A heavy lifter would be used for launching payloads, such as sections of the space station or large satellites, that don't justify the expense and risk of a manned shuttle mission. NASA doesn't have one because of a fateful decision made during the early 1970s by then-administrator James Fletcher and the Nixon White House. It mandated that all payloads fly on the shuttle—creating a monopoly for it—while halting development of unmanned rockets. Commercial and military payloads were given below-cost discounts, a strategy that damaged the American commercial rocket industry and prompted the European Space Agency to press ahead with development of its successful series of Ariane rockets.

The National Launch System, a proposed $10.5 billion family of heavy-lift rockets that was to be shared by NASA and the Air Force, was killed last fall by a cost-conscious Congress lobbied by the builders of smaller existing rockets. "The obvious next step is a National Launch System in several different configurations," says Dr. Jerry Grey, science and technology director at the American Institute of Aeronautics and Astronautics. "The shuttle is becoming obsolete and maintaining its infrastructure is taking up half the NASA budget. And there's nothing in the pipeline. We should learn from this."

Another launch option that Grey and others advocate is using Russia's huge Energiya rocket, the most powerful in existence. He calculates that Freedom could be lofted more quickly and cheaply and with less in-orbit assembly by packing its sections into just four Energiya rockets paired with four space shuttle flights ["Science Newsfront," July]. To the Russians' frustration, NASA has so far shied away from signing up for launches aboard the big rockets, pointing to uncertainties about the long-term stability of former Soviet republics. The prospect of moving too quickly into joint space-launching ventures that could end up falling apart makes U.S. officials uneasy.

Meanwhile, administrator Goldin has before him an unrefuseable offer from the White House: proceed with cutting the space station's cost in half—or get fired.

Finding other uses for money saved by cutting space station spending is very easy. Goldin has no trouble rattling off a list of new goals to pursue. "I envision in the next two decades small and medium-size

[Continued on page 80]

NASA administrator Daniel Goldin (left) chats with Yuri Koptev, director general of the Russian Space Agency. Cooperation is certain, but its extent is still unclear.

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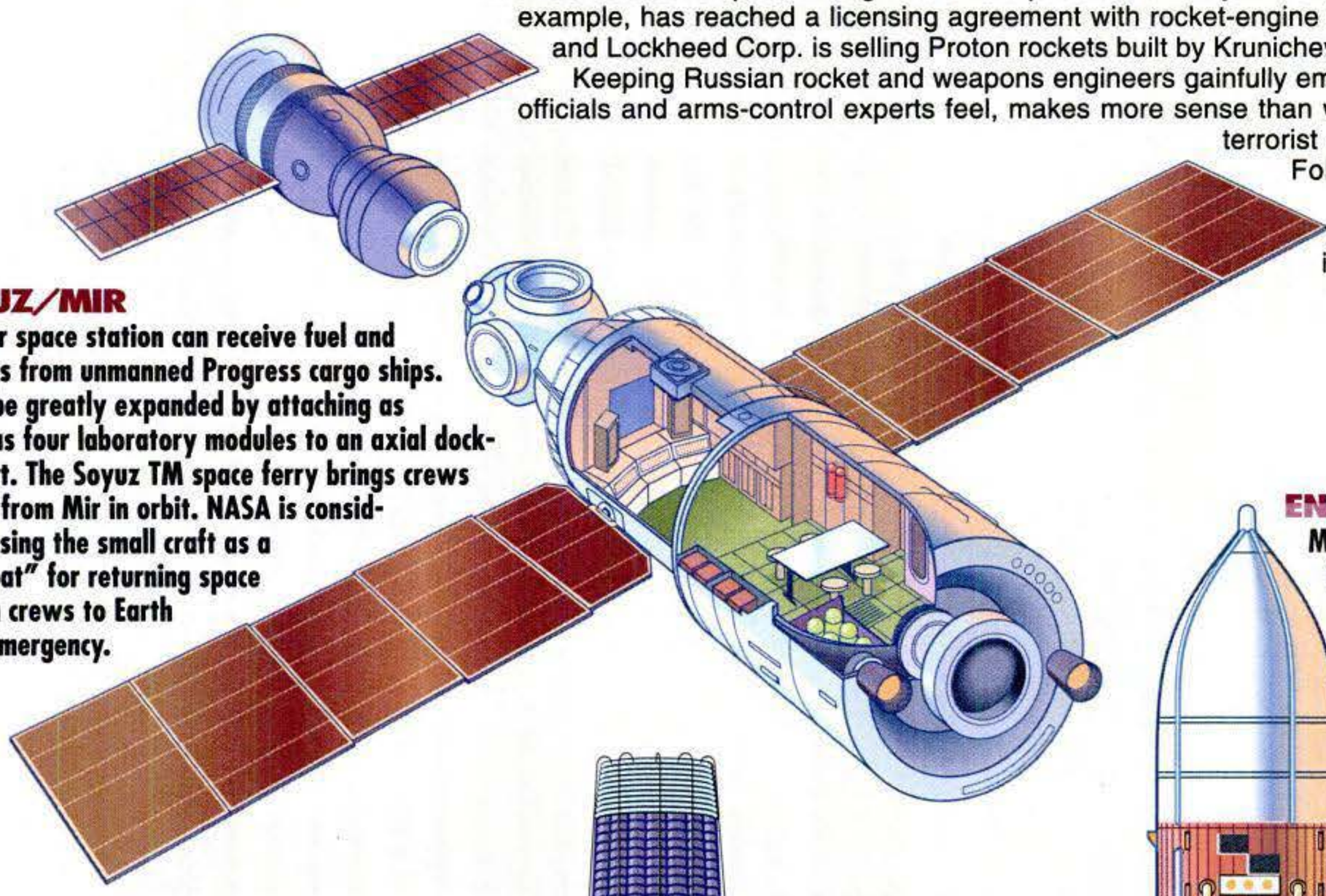
A GALLERY OF RUSSIAN SPACE HARDWARE

The collapse of the Soviet Union has left its large and accomplished space establishment in disarray, virtually broke, and extending a previously unthinkable offer: The cream of Russian space hardware and expertise are for sale at rock-bottom prices.

So far, the United States has agreed to buy a package of equipment including small satellite thrusters, plutonium 239 fuel for space-based power supplies, and the powerful Topaz 2 space nuclear reactor, which has been delivered to the New Mexico Engineering Research Institute in Albuquerque for testing.

After some initial hesitation about patronizing the one-time "evil empire's" space bazaar, government agencies and various companies are taking advantage of unique technologies the former Soviets developed, through hardware purchases and joint ventures. Pratt & Whitney, for example, has reached a licensing agreement with rocket-engine builder Energomash NPO, and Lockheed Corp. is selling Proton rockets built by Krunichev Enterprise of Moscow.

Keeping Russian rocket and weapons engineers gainfully employed, many government officials and arms-control experts feel, makes more sense than watching them emigrate to terrorist states in search of work. Following is a sampling of space hardware our former adversaries are anxious to sell.—*S. F. B.*

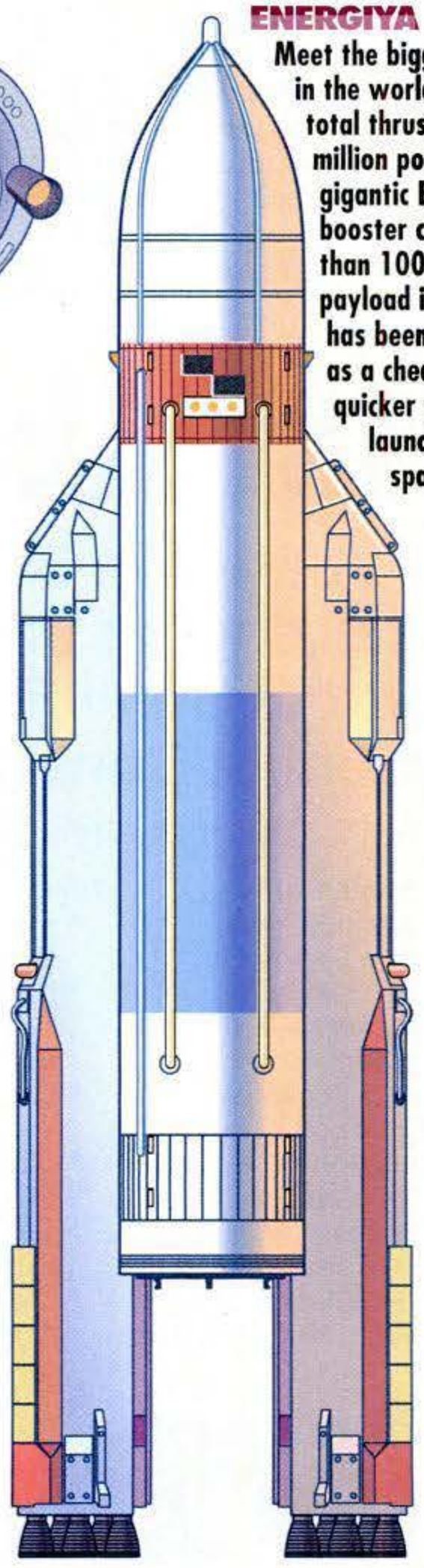


SOYUZ/MIR

The Mir space station can receive fuel and supplies from unmanned Progress cargo ships. It can be greatly expanded by attaching as many as four laboratory modules to an axial docking port. The Soyuz TM space ferry brings crews to and from Mir in orbit. NASA is considering using the small craft as a "lifeboat" for returning space station crews to Earth in an emergency.

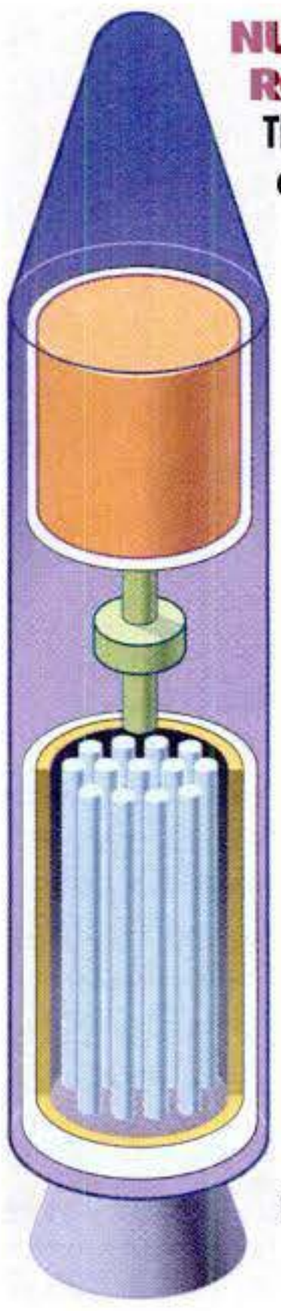
TOPAZ 2 REACTOR

Compact and lightweight nuclear reactors that power spy satellites and other spacecraft have been developed by Russian scientists, who outran their American competitors. Topaz 2 uses an efficient high-temperature process known as thermionic generation to produce electric current from a stream of electrons.



ENERGIYA

Meet the biggest rocket in the world. With a total thrust of 7.1 million pounds, the gigantic Energiya booster can lift more than 100 tons of payload into orbit. It has been proposed as a cheaper and quicker way to launch NASA's space station.



NUCLEAR ROCKETS

The nonchemical (and controversial) way to power spacecraft on long voyages is with an efficient nuclear propulsion system made with special Russian-developed high-temperature materials. Hydrogen gas is heated by passing through the fuel rods of a reactor, then expands through a nozzle to produce tremendous thrust. Launching from atop a chemically fueled first stage rocket engine could lessen the radioactive contamination hazard.

STEVE STANKEWIECZ

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The electric eye

[Continued from page 62]

chip and its associated processing circuitry can be made "with standard, garden-variety silicon processors . . . We have learned that in the eye, ganglion cells are separated on the order of tens of microns. For us that's easy. That's big stuff."

"The approach we'd like to take now," Gray adds, "is to take a step back and start with something very simple, like an array of four sensors . . . What we'd like to do is just sense light. And, if the light's above a threshold, then send out a stimulation pulse to a stimulator on the surface of the retina."

Nevertheless, grafting sensors to living cells is difficult. The stimulator must transfer the information from the light-sensitive chip to the ganglion cells of the retina.

A gentle touch

"You don't want anything mechanically piercing the retina," Humayun explains. "The retina's like Saran Wrap, or thinner, in consistency." The stimulator has to contact the retina to transfer an electrical current, but it must be a gentle touch.

Members of the group at the Research Triangle Institute in Research Triangle Park have started designing and building stimulators. Each stimulator can provide an electrical signal to the ganglion cells for each pixel on the light-sensitive chip. So for a four-pixel chip, the stimulator will have four electrical signals. The first stimulator was created from silicon, as are most electronic chips, including the light-sensitive chip. But the silicon stimulator has sharp edges that could tear the retinal tissue. So the investigators switched to a flexible polymer that could float on the retina's surface.

In the latest experiments this past April on a patient with no light perception at all, a pair of electrodes were inserted into the eye at the same time to see how close they could be brought together before the patient was unable to differentiate the separate points of light. Carol Churchie, who suffers from the same hereditary blindness as his brother Harold, was able to follow the two points of light until the dots were less than a millimeter apart. This suggests that the method will eventually provide fairly high resolution, because the closer pixels are packed together, the more points of light can be stimulated.

The researchers seem confident that they can complete the next step: combining a light-sensitive chip with a polyamide stimulator, surgically implanting the device into a human eye and, perhaps, providing primitive sight to someone who lacks operational photoreceptors. Such a result, though, is some years and many dollars away. One problem yet to be solved is how to install the photocell array in the eye. One technique involves using nanotechnology to construct a folded array that is inserted through a tube and unfurled like an umbrella ["Molecular Marvels," May]. Energy requirements also must be resolved. Though photocells can convert light to energy, it's probably not sufficient to power an electric eye.

Despite the remaining hurdles, Cavin says: "There seems to be kind of an inevitability about this idea. While we don't know exactly how it's going to go, we're encouraged to think that we can make a contribution." It looks like they're already on their way. PS

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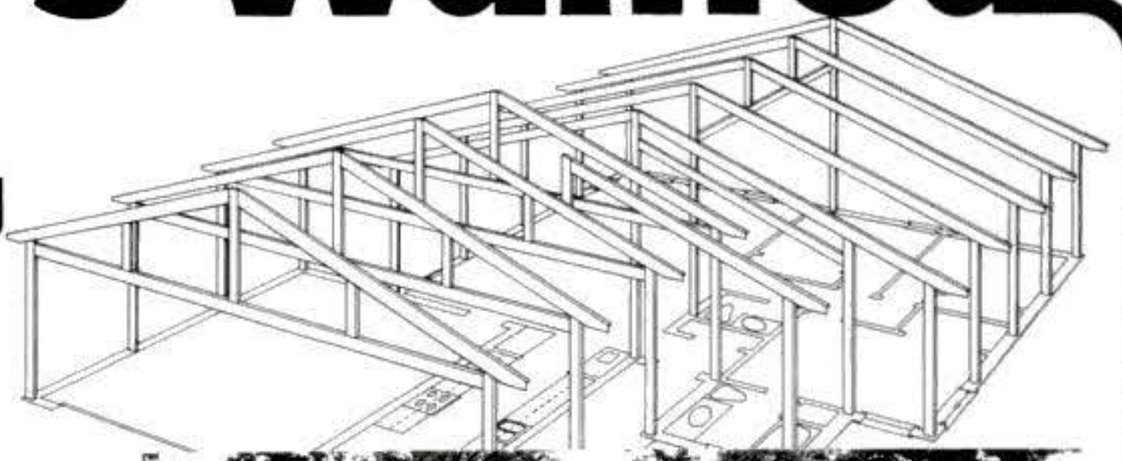

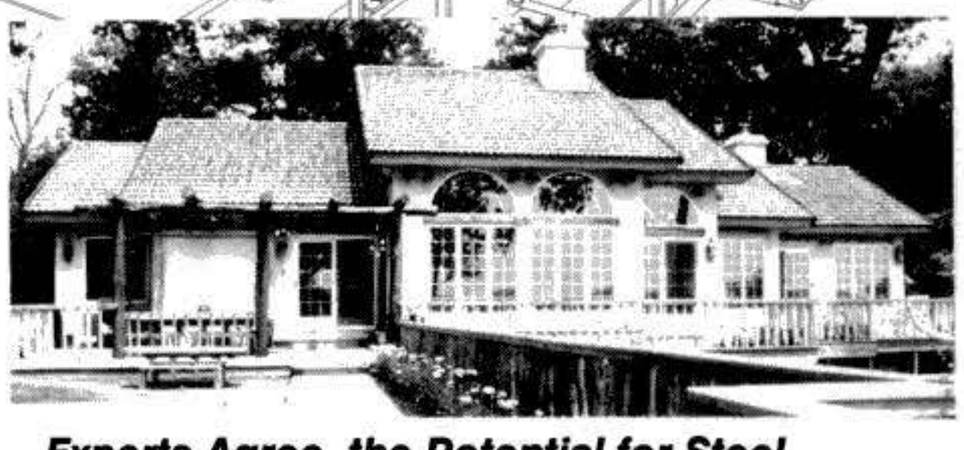

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Science Cité

[Continued from page 67]

though it's not intended for children and is written in English."

Virtually everyone in France has a Minitel, a monitor attached to the telephone. The French Telecommunications Agency has distributed millions of them free. With a Minitel, a person at home can dial into various databases, such as telephone directories. For the cost of a single telephone call, anyone in France can also enter the complete catalog of the médiatheques and see what is available, says Reiner. "If they are registered borrowers from us, they can even put a hold on the material they want. They can tell when an item that is not available will be returned, and they have three days to come and pick it up."

The médiatheques have another very ambitious project involving the Minitel. In the first phase, people will have access to a complete list of all audiovisual materials, with descriptions. In the next phase, users will be able to search in either French or English, and retrieve still images.

Finding jobs

The mission of the Cité does not end with informing and explaining. "Education was always one of the goals of the Cité," says its president, Roger Lesgards. "Another goal, connecting people to jobs, developed only as we gained experience. Now we help young people get professional training, and eventually jobs, in science and technology." The Cité includes a 'passage des metiers' (a corridor of jobs), which houses both an office of the National Employment Agency and an office of the National Education Ministry that specializes in job orientation for young people. These offices offer job leads and advice on choosing a profession.

"Our main target," Lesgards adds, "is to help students. We bring in professionals from all fields and have students watch them as they work." For example, the Cité invited boat builders, who constructed three kinds of boats on site—a runabout, a fishing boat, and a sailing catamaran—as students interested in learning such skills watched.

Finally, Lesgards says, the Cité strives to be the focus of discussions by scientists, philosophers, journalists, and others on the interrelations of science and technology with society and culture.

"Our function is not to say 'science is wonderful, technology is wonderful,' but to explore the connections with modern society, to explain the opportunities, the risks, and the limits." PS

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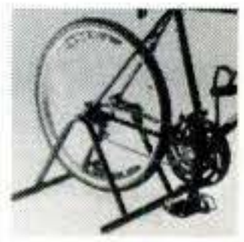

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The frog treatment

[Continued from page 59]

from parts of frogs, lizards, and other beasts. In Stone Age England, members of one pagan clan apparently drank a noxious elixir of oysters, limpets, eels, frogs, and toads during their elaborate burial rituals.

It took modern science until the mid-1970s to realize there was a grain of truth to these myths. At that time, University of Stockholm microbiologist Hans Boman discovered a new class of antibiotics, called cecropins, in a common species of silk moth. In the following decade, interest in animal drugs increased steadily. A team of researchers found pretzel-shaped cecropin molecules in pig intestines, and biologists from the University of California at Los Angeles (UCLA) detected a second class of microbe killers, defensins, in the white blood cells of several mammals.

Bolt out of the blue

Zasloff, a geneticist, joined the fray by accident. As a laboratory head at the National Institutes of Health in the early 1980s, he was performing a series of experiments that involved removing the ovaries from African clawed frogs. Zasloff was impressed by the frogs' ability to recover from the operations quickly, even though they were always put back in aquariums full of naturally occurring bacteria. At first, he didn't dwell on this observation. "Then one summer afternoon it struck me like a bolt out of the blue," he recalls. "Based on everything I knew, the wounds should not be healing." No known natural defense could be killing the germs that must have been present in the murky tanks.

Initial tests to identify the frogs' secret led only to dead ends. Then Zasloff had a new idea: Perhaps the mystery substance was a peptide, a type of chemical that would degrade quickly under most laboratory conditions. He added a second chemical that prevents peptides from degrading, and mixed the frog secretions with bacteria once again. The procedure worked: the bacteria died. He had found the magic bullet.

Over the next two years, Zasloff and his colleagues determined magainin's chemical structure, then synthesized it in the laboratory (so they wouldn't have to kill frogs any longer). They also verified that magainins work like several other animal antibiotics: Instead of merely assaulting one enzyme within a bacterium, as normal drugs do, magainins rip holes in the bacterium's skin—the cell membrane; the contents then flow out like blood from a mortal wound. This "head-to-toe" method of attack, researchers believe, means that a disease cannot become resistant to magainin by means of a simple mutation.

In 1988, Zasloff left the National Institutes of Health to form Magainin Pharmaceuticals, the first company exclusively focused on developing pharmaceuticals from animals.

Looking at sharks

Soon thereafter, serendipity struck again. One day, Yale Medical School researcher and shark expert Dr. John Forrest happened to hear Zasloff give a speech on magainins at a scientific conference in Philadelphia. After the speech, Forrest introduced himself and explained how dogfish sharks, just like African clawed frogs, seem to avoid disease despite often swimming in putrid waters.

The Yale scientist invited Zasloff to visit Mount Desert Island Biological Laboratory in Maine, where Forrest studied sharks each summer. A few months later, the two were looking out over a pool of dogfish sharks at the Maine facility, when Forrest pointed out how pregnant sharks flush their innards with bacteria-laden seawater to rid themselves of waste. Might sharks have some way of disinfecting the seawater?

Zasloff investigated. The results, announced last February in the prestigious journal *Proceedings of the National Academy of Sciences*, "blew my mind," he says. Dogfish sharks do indeed produce a germ-zapping chemical, one even more potent than magainin. But that's just the beginning. The shark drug, dubbed squalamine (the animal's Latin name is *Squalus acanthias*), belongs to a totally different class of chemicals from other animal drugs: It's a steroid.

Because steroids, such as sex hormones, have already been successfully used in many non-antibiotic drugs (birth control pills, for example), it should be easier to develop orally administered drugs from squalamine than from magainin, Zasloff says. What's more, his experiences suggest that untold other classes of natural antibiotics might be awaiting discovery.

Most tantalizing of all is that sharks, as far as researchers can tell, don't get cancer. "Every summer for the past 22 years I've operated on [dozens] of sharks, and I have never seen one with a tumor," is how Forrest puts it. Could squalamine be one of their defenses? Maybe, Zasloff and Forrest speculate.

Despite the promise of animal antibiotics, huge hurdles remain before anyone starts popping pills derived from sharks or other animals. What can go wrong between the test tube experiments and human use? "I can answer that in one word: everything," says Robert Lehrer, one of the UCLA researchers who discovered defensins. Some potential medicines kill bacteria beautifully in the lab but just don't work in animals, he explains; other agents turn out to be too toxic for human consumption.

In fact, the odds are long against any trial drug ever reaching the marketplace. Only one out of every five drugs that reach advanced stages of testing are ultimately approved for sale by the U.S. Food and Drug Administration.

Zasloff's company has started jumping these hurdles. It has chemically synthesized more than 2,000 variants of the frog's magainin and is focusing on ten for human use. One of these, a cream for treating impetigo—a serious skin infection that usually afflicts children—has passed a battery of tests on laboratory animals and recently began its clinical trials on humans. As soon as 1996, according to Magainin Pharmaceuticals vice president Dr. Leonard Jacob, magainin could be approved for impetigo and also for diabetic foot ulcers, a complication of diabetes that can lead to amputation.

A little further down the line are possible remedies for eye wounds and stomach infections, as well as a new mouthwash. Also, in collaboration with Sandoz Pharmaceuticals in East Hanover, N.J., the company is testing magainins for treating ovarian cancer and malignant melanoma, the most deadly form of skin cancer. And, of course, Zasloff's team is delving deeper into the effects of the shark steroid, which was recently patented for use as an antibiotic.

A vast new continent

Whether or not their first drugs work in humans, Zasloff and his colleagues are certain to continue their search for more magic bullets. "It's almost like landing on a new continent," Zasloff says. "You don't know what is out there." One prime goal is an antiviral drug.

At the end of my visit, Zasloff shows me a freezer filled mostly with stacks of maroon shark livers, each sealed in its own Ziploc bag. On the bottom shelf sit blocks of something else. Zasloff won't say what, but it's some kind of animal or fish parts.

Perhaps serendipity will strike again. PS

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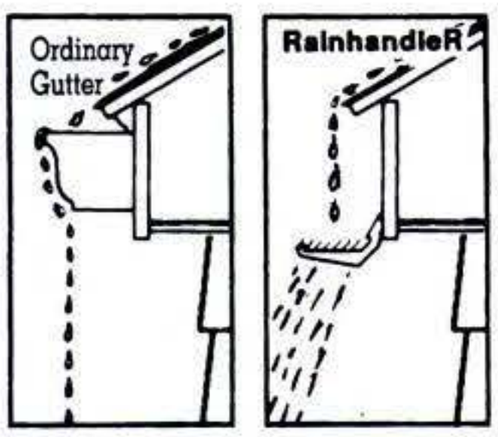

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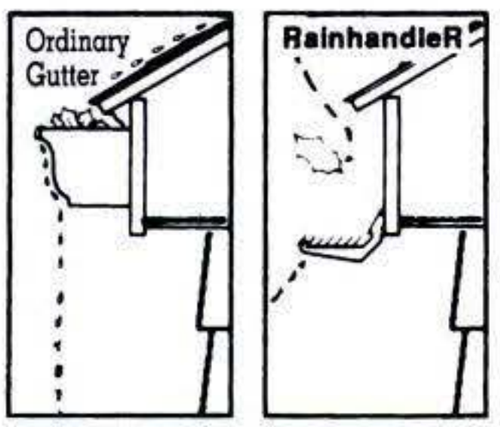

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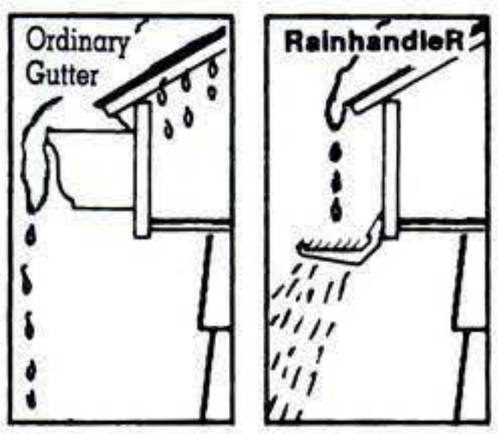

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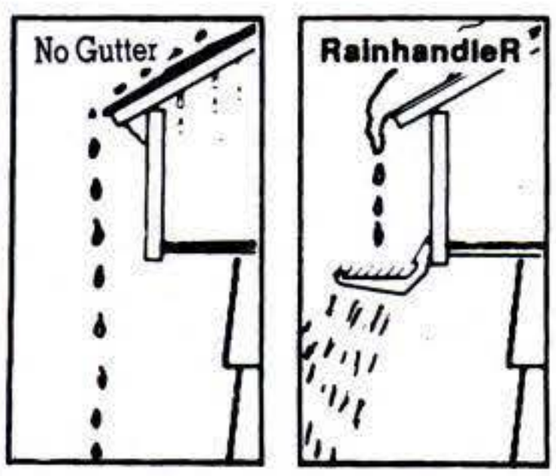

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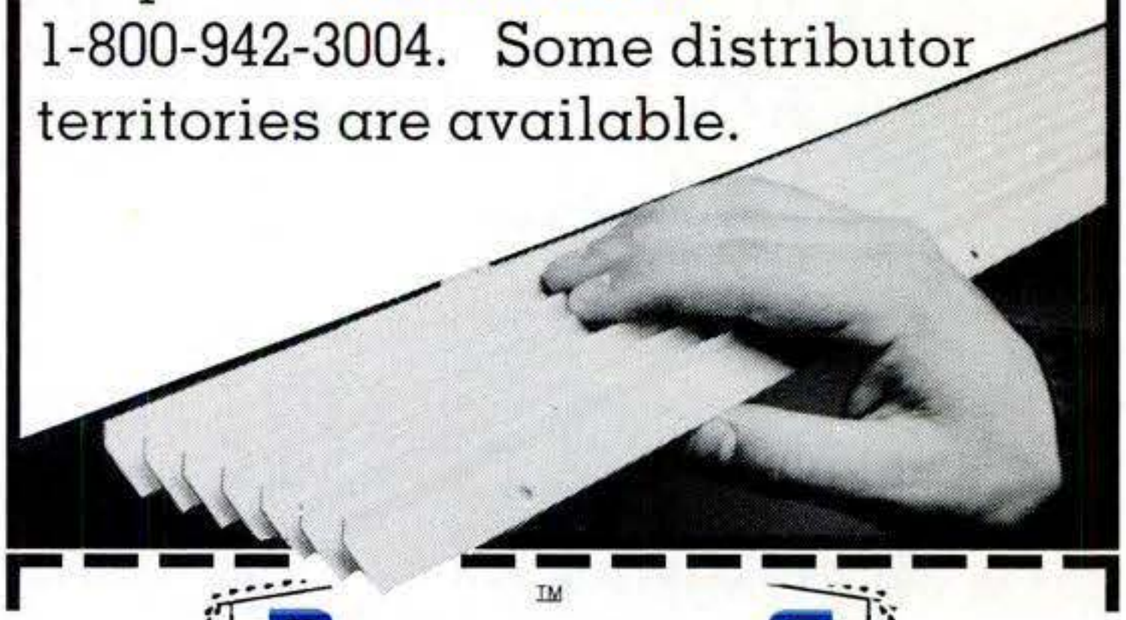

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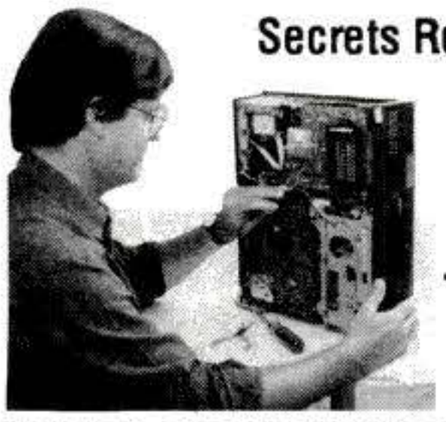

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Space after the race

[Continued from page 75]

robotic probes that will orbit, place rovers on the surface of, and return samples from every major object in the solar system: planets, moons, comets, and asteroids," he says. "Venus is about the same size as Earth and has a runaway greenhouse effect. Why? We think Mars once had a dense atmosphere and running surface water in copious quantities. What happened to it? I submit that comparative planetology will help us better understand the Earth."

Another new mission Goldin is pushing would test NASA's ability to get back to the 1960s way of doing things—soon. The idea is to build two small, simple probes and send them to Pluto, hopefully in 1998. Called the Pluto Fast Flyby, the mission would deliver the probes to the previously unvisited planet and its moon, Charon, seven or eight years after launching. But if the launch date slips much past the millennium, the opportunity to make observations will be lost: Pluto will pass out of reach on its 248-year orbit around the sun.

Each craft's weight is to be kept to 330 pounds, with a scientific instrument package weighing a mere 15 pounds. Total program cost is estimated to be no more than $400 million—ultra-cheap by today's standards. Adapting antenna dishes left over from the 1970s' Viking Mars probes is one way Pluto Flyby designers have found to save money.

The gluttonous shuttle

Much of the money the space agency spends goes to the space shuttles. Although NASA officials argue over the figures, estimates of the total cost of operating the shuttle run to a billion dollars or more per flight. The shuttle and the space station are financial black holes destined to crowd out NASA's other activities unless they are plugged.

At risk of losing their funding would be three major space science missions: The Earth Observing System (EOS), a constellation of environmental monitoring satellites that are part of a program called "Mission to Planet Earth" ["Eyes on the Earth," July '92]; the Advanced X-Ray Astrophysics Facility (AXAF), a craft that will scan the universe in the X-ray band of the electromagnetic spectrum; and the scaled-down Cassini probe to Saturn.

"Is there any higher priority for us as a nation than understanding the sources and global impact of pollution?" Goldin said. "Mission to Planet Earth will help us to understand the fundamentals of our environment and to separate out the natural and human-induced factors so that policymakers can make decisions based on hard facts, not on guesses."

The agency's other major activity is its aeronautics work, sometimes referred to as the "little A in NASA," conducted at its three major research centers. The administration's heightened focus on technology will boost aeronautics research, with the goal of injecting new technical vitality into the aerospace industry; the United States has seen its share of the world market for products such as airliners slide to 68 percent in 1991 from 90 percent in 1970.

Despite its overall trimming, NASA's five-year budget plan provides for a 55 percent increase in funding for aeronautics projects. These include developing an environmentally benign supersonic airliner, advancing jetliner efficiency, breathing new technology into the backward and moribund general-aviation industry, pursuing flight tests of hypersonic scramjet engines, and modernizing the country's wind-tunnel facilities.

Two recent, quietly announced bureaucratic changes tipped insiders to the depth of the Clinton team's space policy shift. One was the termination of the White House National Space Council; the other, the shutting down of NASA's Office of Exploration, a small study group tasked with developing manned moon and Mars missions, after Congress zeroed its budget.

The National Space Council was an interagency coordinating group established during NASA's early days. Disbanded during the Nixon administration and revived by President Bush with Dan Quayle as chairman, the council's members included the NASA administrator; the secretaries of State, Defense, Treasury, and Commerce; the budget and Central Intelligence Agency directors, and the president's national security adviser. One of the council's goals was seeking economies through sharing hardware, technology, and procedures among those branches of the government with interests in space. These included the Defense Department and the Department of Energy, which builds nuclear-powered electric generators for spacecraft. The council's role has now been assumed by science

adviser Gibbons' Office of Science and Technology Policy, which sets national goals in a much broader range of areas.

A national identity

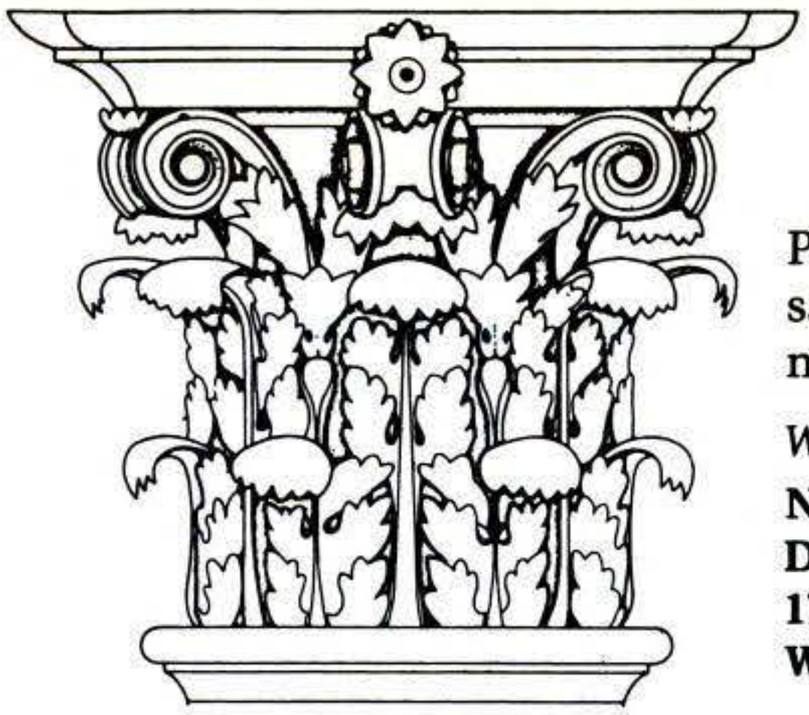
John Pike, director of the Space Policy Project at the Federation of American Scientists in Washington, D.C., and an adviser to President Clinton during his election campaign, regrets the National Space Council's demise. "You simply do not have a point of advocacy at the White House that will make the case for space in other than scientific or competitiveness terms. The real reason we went to space was to make ourselves feel good about being Americans—national identity—and that's enough. You can skip all the talk about Tang and Velcro."

A radical but conceivable result of canceling the space station, Pike says, could be that NASA might suddenly appear to be superfluous. "If you're not flying the shuttle, you don't have a piloted space program. Then what do you need NASA for? You could give the remaining $3 billion or $4 billion worth of programs to the Department of Transportation, the Environmental Protection Agency, and Caltech's Jet Propulsion Laboratory—and the last one out turn off the lights."

What's next for now? A Russian cosmonaut is scheduled to fly on the space shuttle *Discovery* this fall. And in 1995, a shuttle will use a Russian automated docking system to visit the orbiting Russian Mir space station. Medical diagnostic equipment carried on the shuttle will monitor the health of Russian cosmonauts and an American astronaut aboard Mir—which translates as both "peace" and "Earth." These practical, confidence-building steps into the post-Cold War Space Age remain likely to be carried out, whatever the outcome of the current space program review.

Cooperation and sheer excitement are reasons enough for working toward a visit to Mars with the Russians, argues John Pike. "Since I was a little kid, I have thought spaceflight was the defining activity of this period," he says. "The Air and Space Museum isn't full yet."

And until a coherent space program once again becomes a national—or perhaps global—imperative, the museum is likely to have room to spare for a long time to come. *(See From the Editor for late news on the space station design.)* PS



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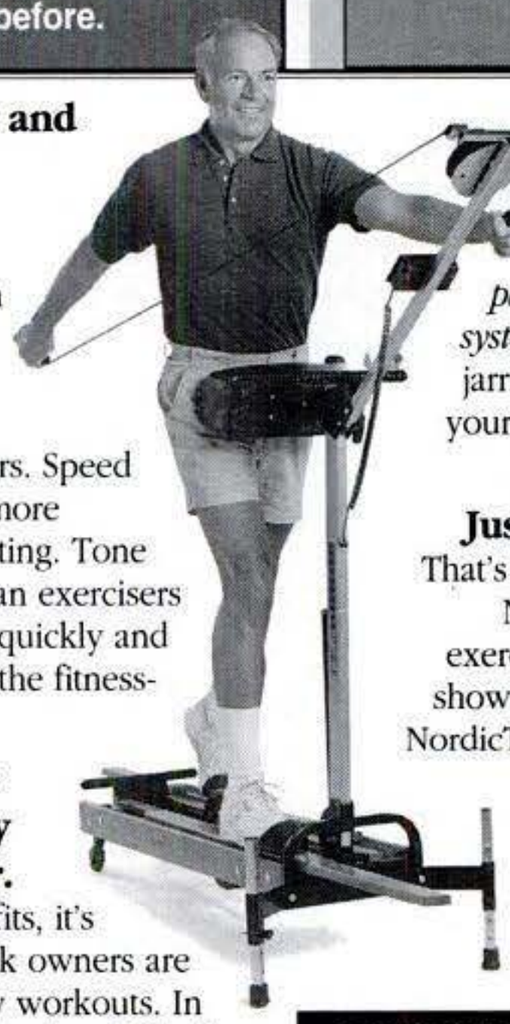

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Cold fusion

[Continued from page 51]

is being produced by nuclear reactions.

The one exception to this missing link—an exception that is stirring considerable excitement among cold fusion advocates—is coming from an unexpected source, Nippon Telephone & Telegraph Corp.'s (NTT) basic research labs in Tokyo. NTT physicist Eiichi Yamaguchi takes a piece of palladium, coated on one side with gold, and saturates it with deuterium gas. The palladium is put into a vacuum chamber and is subjected to an electric current. Two to three hours later the palladium suddenly begins to heat up, generating as much as five watts of excess heat for 10 or 15 minutes. Then it releases a burst of gas containing relatively large amounts of helium-4.

"This gives the first definite evidence for the reality of cold nuclear fusion in solids," Yamaguchi said last October at an international cold fusion meeting in Nagoya, Japan. "The amount of produced helium-4 gas was strongly correlated to the excess heat evolution," he added.

Light-water fusion?

The Yamaguchi experiment might have dominated the talk at the Nagoya gathering had it not been for another Japanese procedure. During the meeting, recalls theoretical physicist Peter Hagelstein of MIT, two electrolytic cells were set up on a table in a hallway outside the main conference room. Ordinary thermometers mounted on the cells showed that the experimental cell was 15°C hotter than the control cell, he says. The thermometers indicated the experimental cell was putting out three times more power, as heat, than it was consuming.

The Japanese woman standing behind the table informed Hagelstein that the bubbling hot cell used ordinary light water spiked with potassium carbonate for the electrolyte, rather than heavy water. The cathode, she said, was a highly porous form of nickel, not palladium.

"I was impressed," says Hagelstein, who tends toward understatement.

The woman was chemist Reiko Notoya of the Catalysis Research Center at Hokkaido University in Sapporo. Notoya is one of five researchers who claim to have generated excess heat during the electrolysis of ordinary water. She is so confident of her experiment's reproducibility that she offers to perform it on demand, as she did at the Nagoya meeting and later last fall at MIT.

Most researchers credit the concept of light-water cold fusion to a scientist in Lancaster, Pa., who doesn't believe he's dealing with fusion at all. Randall L. Mills is a physician who holds an undergraduate degree in chemistry.

"Grand unified theory"

At the height of the controversy over the Pons-Fleischmann announcement, Mills announced that he had succeeded in producing excess power by electrolyzing light water instead of heavy water. The cathode was porous nickel instead of palladium, and the light water was spiked with potassium carbonate instead of lithium, he said. He claimed that the energy-producing phenomenon was an electrochemical process rather than "cold fusion." He proposed a theory in which energy is released by the collapse or shrinkage of the electron shell around a hydrogen atom. The theory defied the basic concepts of quantum physics and thus required his own new "grand unified theory" uniting the bases of chemistry and physics.

Mills subsequently described his theory and experiments in a paper published in *Fusion Technology* in the summer of 1991. The following March, *Fusion Technology* carried another report from V. C. Noninski, a Bulgarian electrochemist who at that time was a visiting scholar at Franklin and Marshall College in Lancaster. Noninski claimed he too had gotten excess power from a Mills-type experiment.

Others are reporting successful electrolytic experiments with light water spiked with various salts of potassium, sodium, and other elements. Physicist Bush of California Polytechnic says that by last fall's Nagoya meeting he and his colleague, Robert Eagleton, had built and operated 16 electrolytic cells using light water, almost all of which have produced excess heat.

And researchers from India's Bhabha Atomic Research Center report they have run 29 different light-water electrolytic cells and have gotten up to 70 percent excess heat from many.

"I don't know for certain if it's real or not," says Hagelstein. But, he adds, "when I saw the Notoya experiment I thought it was the single outstanding confirmation of the Mills experiment."

Most researchers say they can't subscribe to Mills' theory on "shrinking" hydrogen atoms to explain the excess power. But the fact that light water lacks deuterium also rules out what physicists generally call nuclear fusion, that is, deuterium-deuterium fusions or deuterium-tritium fusions. Bush in California and Notoya in Japan, both of whom use potassium carbonate to salt their light-water electrolyte, say they detect calcium in the electrolyte after the experiment has run for a while. They note that if a hydrogen nucleus—a proton—is fused with a potassium nucleus, the result would be a calcium atom.

Regardless of what is producing the heat in the light-water experiments, at least one company is pushing to capitalize on the results. The Mills experiments are the basis for an electrolytic cell that has been in continuous operation since March 1992 at Thermacore Inc. in Lancaster, says engineer Robert Shaubach, the company's manager of development operations. He says the cell is consuming 18 watts of power while producing 68 watts, for an excess heat production of 50 watts.

Still skeptics

Nevertheless, cold fusion researchers haven't yet proven their heavy-water experiments to orthodox physicists, much less the ones using light water. "If you buy the excess heat measurements, then you have to invent some kind of nuclear process to explain them," says Richard Petrasso, a "hot fusion" physicist at MIT. "I just haven't bought into the heat claims yet. I think there is a subtle mistake." But, he adds, "if it's a mistake, it's a very interesting mistake.

"I guess I'll believe it when someone drives a car up here [to Cambridge, Mass.] from New Jersey" powered by cold fusion, Petrasso says.

(For a highly detailed, readable blow-by-blow account of the controversy up to the closing of Utah's National Cold Fusion Institute, readers may wish to peruse Gary Taubes' new book, *Bad Science—The Short Life and Very Hard Times of Cold Fusion*.)

Whatever the eventual verdict on cold fusion—and there are few "last judgments" in science—the scientific effort it has spawned has ensured it a niche in history. The National Science Foundation has funded a cold fusion archive at Cornell University in Ithaca, N.Y. Any researchers who either joined in or were merely bemused spectators of the cold fusion spectacular have been invited to contribute relevant materials, from laboratory notes to formal presentations.

"Since this is a wonderful example of how scientists tackled a new and controversial issue," says Cornell University's Bruce Lowenstein, a science historian and the archive's director, "we want to be sure that much of the ephemeral material created in the process gets saved. We hope that the archive will be a resource for historians and sociologists of science in the future." PS

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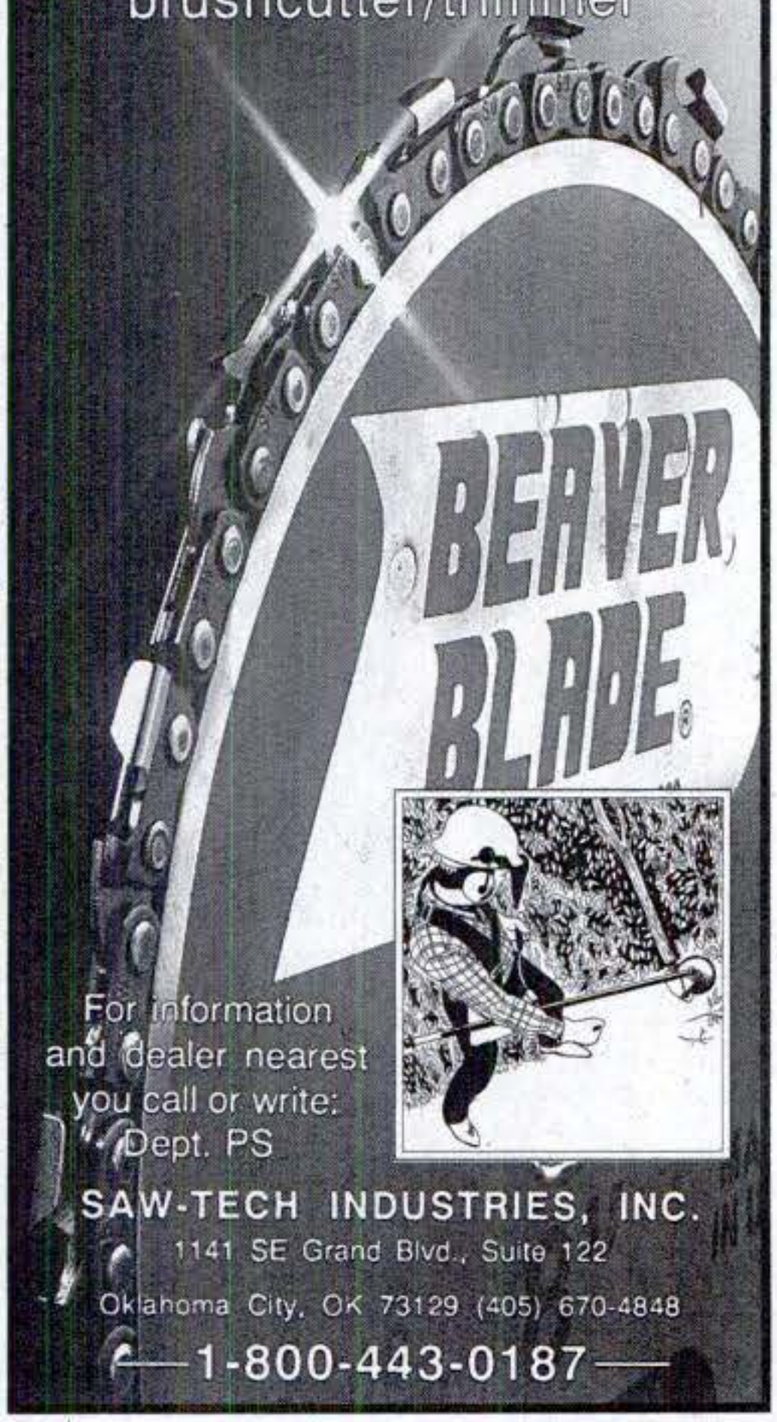

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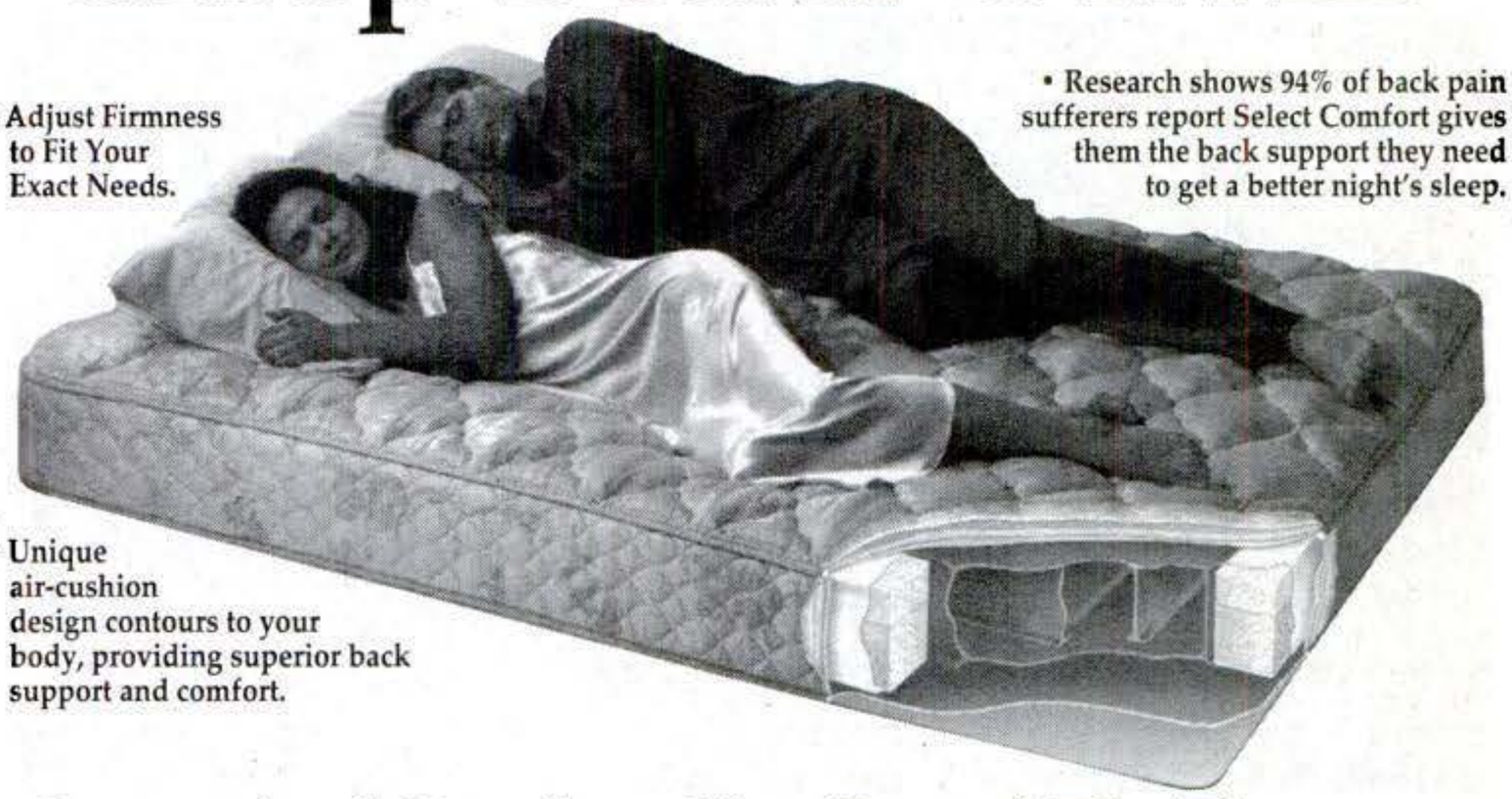

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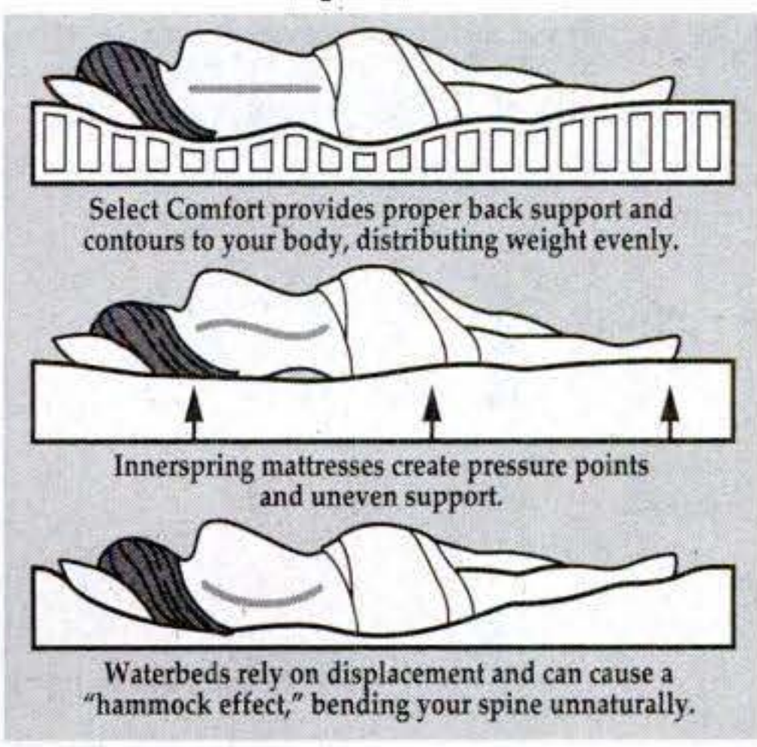

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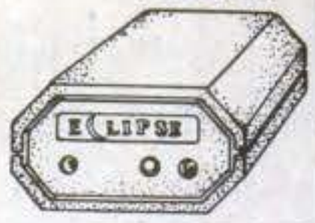

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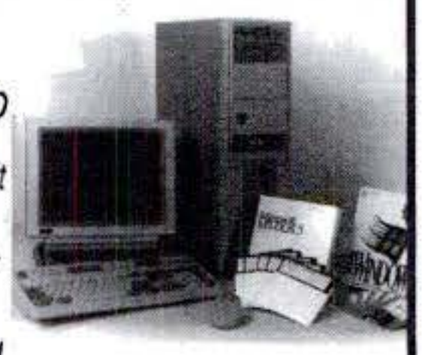

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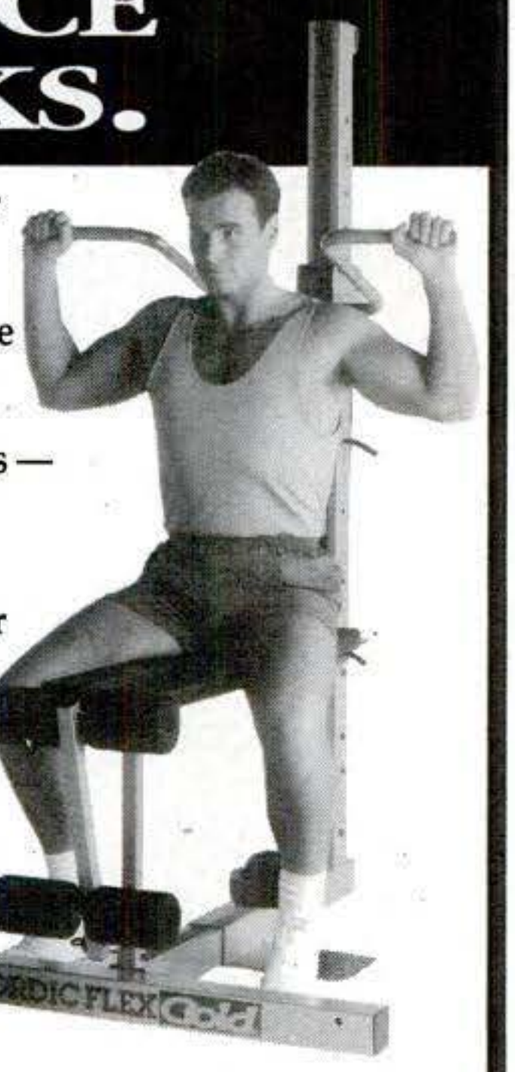

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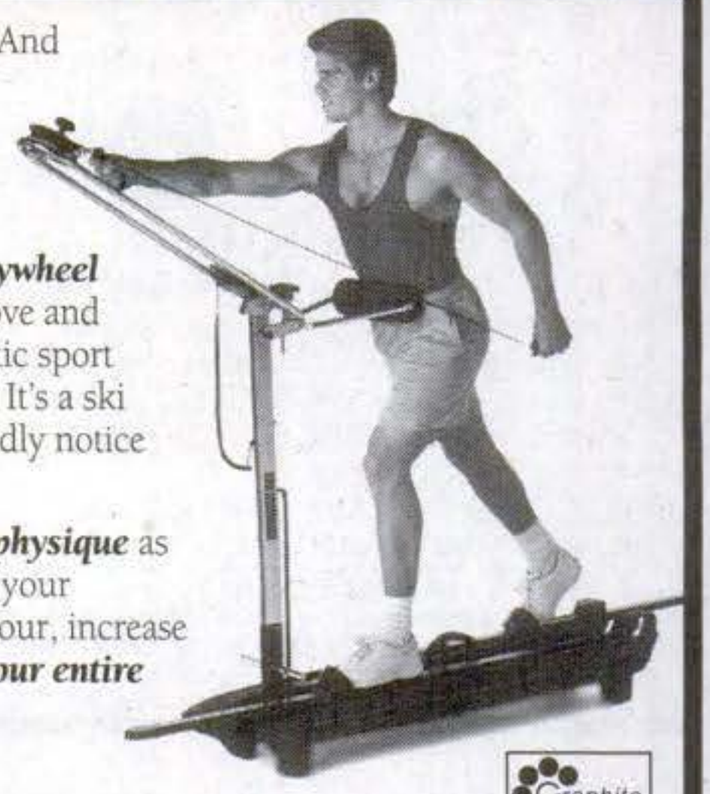

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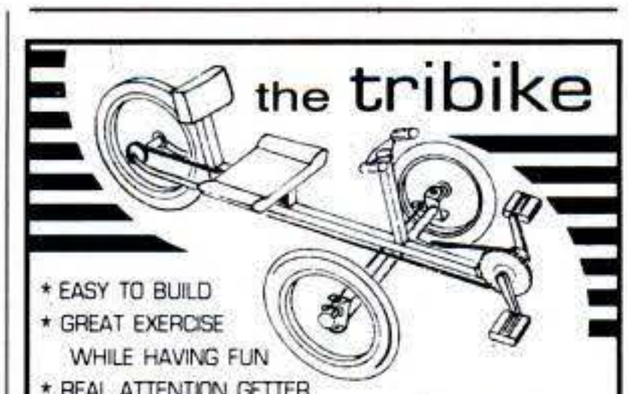

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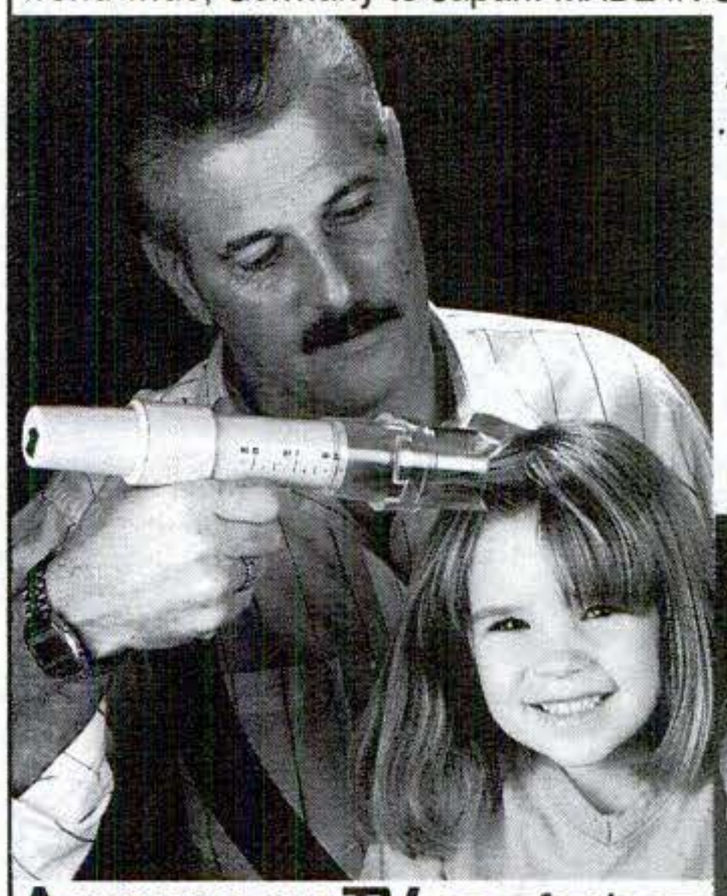

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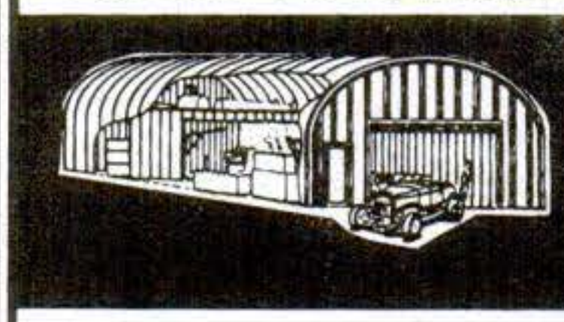

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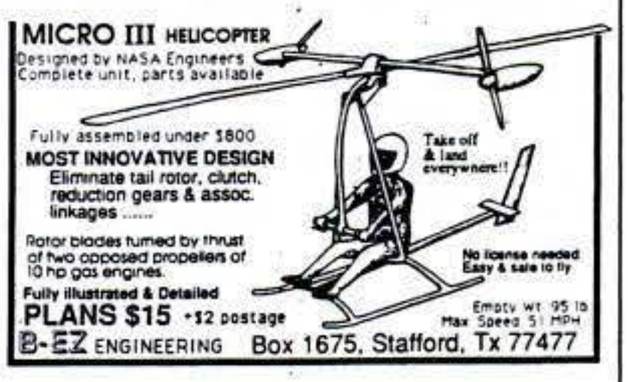
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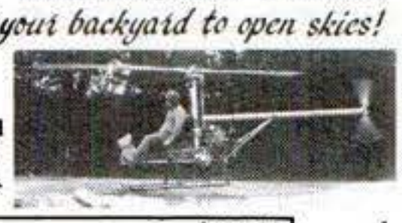

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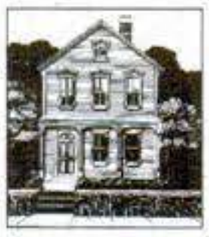

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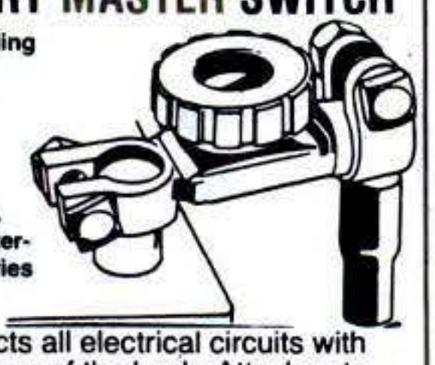

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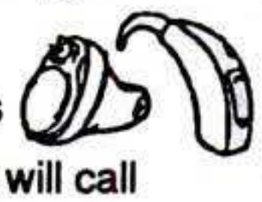

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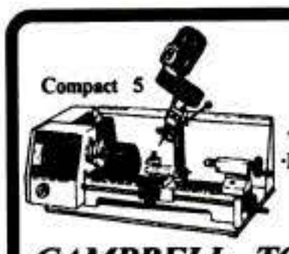

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LOOKING BACK

EDITED BY SUZANNE KANTRA

100 YEARS AGO

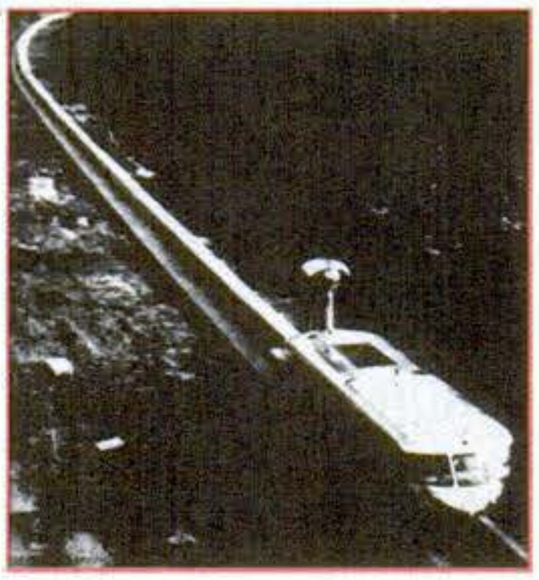
OIL ON TROUBLED WATER

In the wake of environmentally damaging oil spills in recent years, intentionally dumping oil overboard into the sea seems incomprehensible. However, sailors once believed that a film of oil could calm the rough seas surrounding their ship. The practice continued through the early 1900s, but was abandoned after the theory was disproved. —*August 1893*

75 YEARS AGO

AIRMAIL

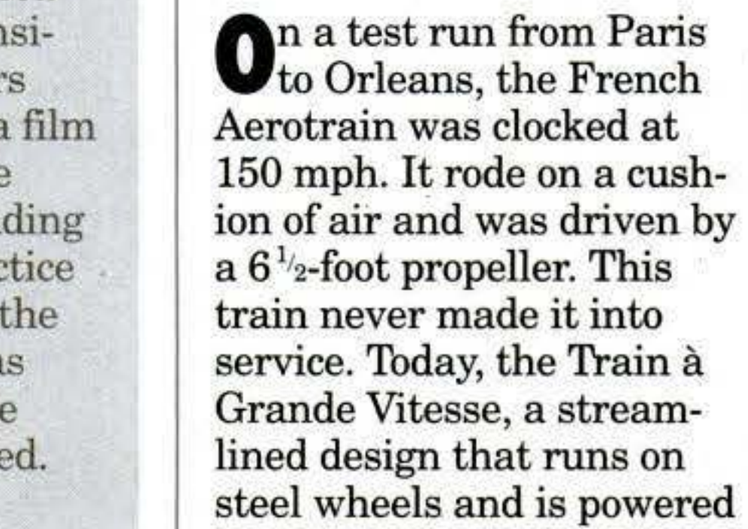
Future histories of civilization will record May 15, 1918, as the day marking the beginning of a new epoch in the evolution of the mail service," proclaimed the editors after the first mail delivery by airplane. In fact, only six to eight hours were gained over rail service, and there were no guarantees that the mail would get there more quickly if the plane ran into bad weather. Today, express mail carriers such as DHL and Federal Express use planes to promise overnight delivery just about anywhere in the world. —*August 1918*



25 YEARS AGO

RIDING ON AIR

On a test run from Paris to Orleans, the French Aerotrain was clocked at 150 mph. It rode on a cushion of air and was driven by a 6½-foot propeller. This train never made it into service. Today, the Train à Grande Vitesse, a streamlined design that runs on steel wheels and is powered by electricity, travels from Paris to Lyon, Brittany, and Lille at a top speed of 200 mph.—*August 1968*



75 YEARS AGO

TANKS: THE NEW CAVALRY

No adequate method has been devised to protect horses against rifle and machine gun bullets and shells. So military men have invented an armor-protected horse—the tank, which is light, mobile, and wriggles in and out of shell craters with ease." The tank had 1,200 pounds of armor and two machine guns, and a top speed of 12 mph. Today's Abrams M1A2 tank has 6,178 pounds of armor, including a 120-mm gun. Its top speed is 41.5 mph.—*August 1918*

50 YEARS AGO

DOWN UNDER

The Narrows Tunnel would have connected Staten Island to Brooklyn, N.Y., under the entrance to New York harbor. The tunnel was to be built on dry land in sections and each piece lowered into the water. The tunnel was never built. Instead, the Verrazano-Narrows Bridge, the largest suspension bridge in the world today, was constructed to link the two boroughs in 1964. —*August 1943*

25 YEARS AGO

PUBLIC SECURITY

The heightened concern for safety following the assassinations of John and Robert Kennedy and Dr. Martin Luther King caused law enforcement agencies to turn to new technologies to help protect the public. Much of the resulting equipment is in use today: metal detectors, computers for fingerprint analysis, helicopters for surveillance, personal communication devices such as walkie-talkies, and the universal emergency phone number, 911.—*August 1968*

100 YEARS AGO

LIGHTNING ADVICE

These tips on lightning protection are as valid today as they were 100 years ago:

"Get a good iron or copper conductor—rod or tape form.

You can't overdo it when making a good grounding point. The small resistance of even one ohm may be dangerous with an intense flash.

If the conductor at any point goes near water or gas mains, connect it to them. Small fusible pipes and indoor gas pipes in general should be avoided.

Independent grounds are preferable to water and gas mains.

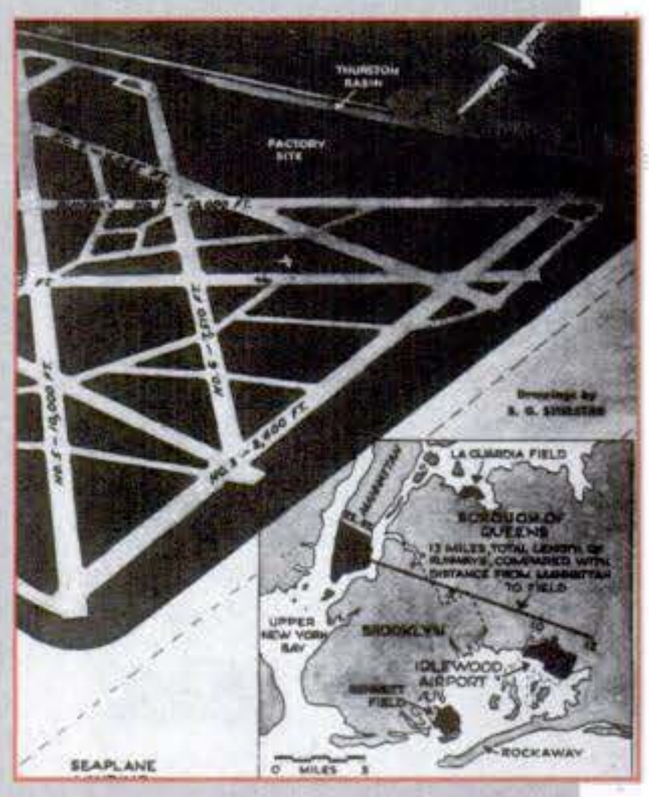
One who lives to see lightning need not worry.

The notion that lightning never strikes twice in the same place is erroneous. We have many cases disproving this."—*August 1893*

50 YEARS AGO

FUTURE-PERFECT AIRPORT

Described as New York mayor F. H. La Guardia's "aerial wonder project," Idlewild, now John F. Kennedy International Airport, was designed to handle 950 flights daily. "Every hour on the hour a big airliner will hop off for a trip across the Atlantic. Weekend jaunts to London and Paris will be as easy as visits from New York to Atlantic City are now," stated La Guardia. Today Kennedy handles about 760 flights per day.—*August 1943*



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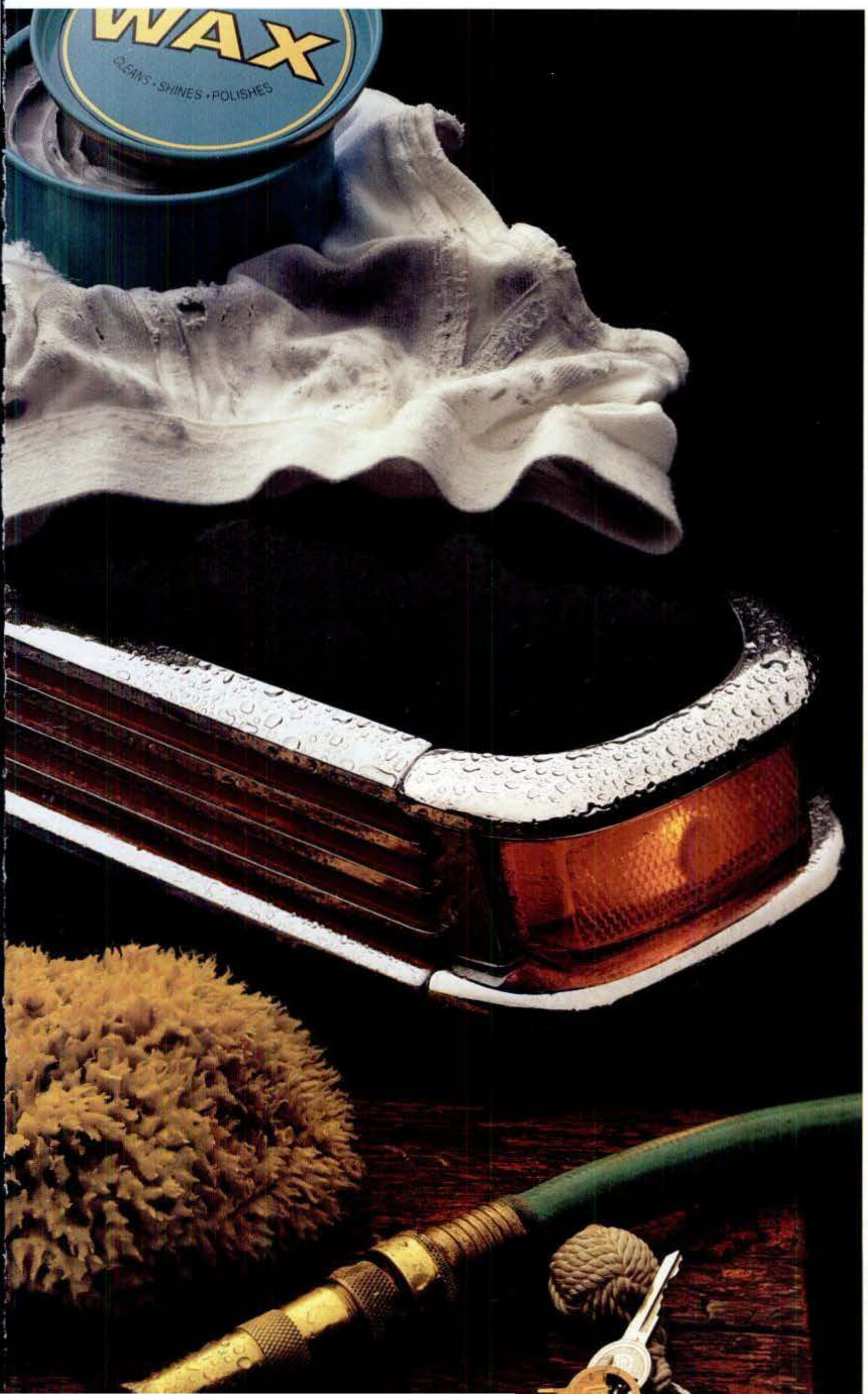
What will your underwear be doing a year from now?



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